Prevalence of obesity and its associated risk of diabetes in a rural Bangladeshi Population

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Abstract

Background:

People in the developing countries are increasingly vulnerable to the worldwide epidemic of obesity. It is a common modifiable risk factor for all the cardiometabolic diseases including type 2 diabetes (T2DM). Population-based data on the prevalence of obesity in rural Bangladeshi adults based on newly proposed cut off points for Asian population have scarce until recently.

Objective:

To assess the prevalence of general and central obesity in a rural Bangladeshi population and their association with T2DM.

Methods:

This study data have retrieved from Chandra Rural Diabetes Study, a population-based cross-sectional study which was conducted in a rural community called Chandra, 40 km. north of Bangladesh's capital, Dhaka in 2009. The survey was carried out in two phases. The first phase consisted of household census of the total population residing in the study locations. Based on the census results, a list of all men and women aged 20 years and above was selected in the second phase. Required numbers of individuals were selected following a random procedure. Ten villages were randomly selected from five areas. The total population of these villages was approximately 20,000 aged ≥20 years. For this study, 3000 individuals were randomly selected and among them 2376 (79.2%) participated. Structured questionnaires including socio-demographic parameters, anthropometric measurements, blood pressure (BP), and blood glucose values were recorded. Age adjusted data for anthropometric indices and diabetes risks were assessed and their relationships were examined. Newly proposed cut off points for Asian population had been used to define general obesity defined by body mass index (BMI) and central obesity defined by both waist circumference (WC) and waist hip ratio (WHR).

Results:

The age standardized prevalence of overweight (BMI 23-<25 kg/m^2) and obesity (BMI ≥25 kg/m^2) were 17.7 (95% confidence interval (CI): 16.1, 19.2%) and 26.2% (95% CI: 24.4, 27.9%), respectively. The age standardized prevalence of central obesity based on WC (M ≥90 & F ≥80 cm) and WHR (M ≥0.90 & F ≥0.80) were 39.8% (95% CI: 37.9, 41.7%) and 71.6% (95% CI: 69.8, 73.4%) respectively. Among the study population 88% had both high BMI (≥25 Kg/m^2) and high WC (M ≥90 & F ≥80 cm) and on the other hand, 92.7% had both high BMI (≥25 Kg/m^2) and high WHR (M ≥0.90 & F ≥0.80). The result shows that prevalence of central obesity was more in female than male. Study shows middle age, medium and high socioeconomic status (SES), illiterate, primary and secondary education levels, physical inactivity, high consumption of carbohydrate, protein and fat, were some significant risk indicators for general and central obesity. The adjusted odd ratio (OR) was highest for BMI ≥25 (OR: 2.12, P<0.001) for predicting T2DM compared to BMI ≥23 (OR: 1.26, P = 0.228), BMI ≥27.5 (OR: 1.93, P = 0.0.002) and BMI ≥30 (OR: 1.78, P = 0.098). Study also indicates that WHR predicted better T2DM risk than WC and BMI for both men and women. ROC analysis showed the optimal cut-off points for T2DM detection were at a BMI of 21.2 kg/m^2 in men and 21.8 kg/m^2 in women, WC 82 cm in men and women and WHR 0.93 and 0.87, respectively.

Conclusions:

It is apparent that obesity is increasing even in poor rural population. In rural Bangladeshi population, the prevalence of both general and central obesity was high among both sexes with the use of newly proposed cut off points for Asian population. Women presented with more central obesity than men. Gender, diet, physical activity, education level, socioeconomic condition, and smoking were associated with the prevalence of obesity. Compared with BMI, measures of central obesity, WHR and WC showed a better association with the risk of T2DM for both gender. Longitudinal follow-up studies are needed to confirm the risk indicators for obesity found in this study.

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Abbreviations

AIDS	Acquired immunodeficiency syndrome
ANCOVA	Analysis of Covariance
AUC	Area Under the Curve
BCE	Before the Christian Era
BDT	Bangladeshi Taka
BDHS	Bangladesh Demographic Health Survey
BIRDEM	Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders
BMI	Body Mass Index
BP	Blood Pressure
CHD	Coronary Heart Disease
CHOD-PAP	Cholesterol Oxidase – Para amino phenazone
CI	Confidence Interval
CVD	Cardiovascular disease
DAB	Diabetic Association of Bangladesh
DBP	Diastolic Blood Pressure
DM	Diabetes Mellitus
FBG	Fasting Blood Glucose
FPG	Fasting Plasma Glucose
FTO	Fat Mass and Obesity
GDM	Gestational Diabetes Mellitus
GDP	Gross Domestic Product
GPO-PAP	Glycerol Phosphate Oxidase –Para amino phenazone
HTN	Hypertension
HIV	Human immunodeficiency virus infection
HDL-C	High Density Lipoprotein Cholesterol

HNPSP	Health, Nutrition, Population Sector Programme
IDF	International Diabetes Federation
INFS	Institute of Nutrition and Food Science
IFG	Impaired Fasting Glucose
IGT	Impaired Glucose Tolerance
LDL-C	Low Density Lipoprotein Cholesterol
LMCs	Low- and Middle-Income Countries
MONICA	Monitoring of Trends and Determinants in Cardiovascular Disease
MS	Metabolic Syndrome
NEM	National Committee for Medical and Health Research Ethics
NGO	Non-Government organization
NCDs	Non-communicable Diseases
NCEP	National Cholesterol Education Program
NHANES	National Health and Nutritional Examination Survey
OR	Odds ratio
OAC	Obesity in Asia Collaboration study
OGTT	Oral Glucose Tolerance Test
ORS	Oral Rehydration Salts
ROC curve	Receiver-Operating Characteristics Curve
SBP	Systolic Blood Pressure
SEA	South and East Asia
SES	Socioeconomic Status
TG	Triglycerides
T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
T-Chol	Total Cholesterol
UK	United Kingdom
UN	United Nation

USA	United State of America
USD	United State Dollar
VPG	Venous Plasma Glucose
WC	Waist Circumference
WHO	World Health Organisation
WHR	Waist Hip Ratio
WP	Western Pacific
2-h PG	2-hour Plasma Glucose

Chapter 1: Introduction

1. 1 Overview of Bangladesh

1.1.1 Geography

Bangladesh, officially known as the People's Republic of Bangladesh is located in the northeastern part of the Indian subcontinent on the biggest delta in the world. All three sides of Bangladesh are generally surrounded by India with Myanmar on the southeast and the Bay of Bengal to its south. Together with the Indian state of West Bengal, it makes up the ethno-linguistic region of Bengal. In the official Bengali language, the name Bangladesh means "Country of Bengal". It has a total area of 144,000 square kilometers. It is among the most densely populated countries in the world and has a high poverty rate and vulnerable to natural disaster. As the World Bank notes in its July 2005 country brief, the country has made exceptional progress in human development in the areas of literacy, gender parity in schooling and reduction of population growth **(1).** However, Bangladesh continues to face a number of major challenges, including widespread political and bureaucratic corruption, and economic competition relative to the world.

Figure 1.1: Geographic location of Bangladesh

1.1.2 Land and Climate

Bangladesh is a land of rivers that crisscrossed throughout the mostly flat territories of the country. A humid, low-lying, alluvial region, Bangladesh is composed mainly of the great combined delta of the rivers Padma, Jamuna and Meghna, with a network of numerous rivers and canals. Along the southwestern coast is the Sundarbans, a mangrove swamp area with numerous low islands. Part of the country there are a few small hills in the north and southeast, but most of the country is relatively low and flat. Small portion of the country is more than 12 meters above sea level and when the normal monsoon starts, one third of cultivated land is flooded. However, the estuaries of the Ganges and Bramhaputra rivers have enriched the countryside with lush, green and very fertile alluvial soil. Straddling the Tropic of Cancer, Bangladeshi climate is tropical with a mild winter from October to March, a hot, humid summer from March to June. A warm and humid monsoon season lasts from June to October and supplies most of the country's rainfall. Natural calamities, such as floods, tropical cyclones, tornadoes, and tidal bores occur every now and then throughout the year, combined with the effects of deforestation, soil degradation and erosion.

1.1.3 History

Remnants of civilization in the greater Bengal region date back four thousand years, when the region was settled by Dravidian, Tibeto-Burman, and Austro-Asiatic peoples. The exact origin of the word "Bangla" or "Bengal" is not known, although it is believed to be derived from Bang, the Dravidian-speaking tribe that settled in the area around the year 1000 BCE **(2).** Due to its location at the intersection of South and South East Asia and its fertile agricultural land, it has been invaded and influenced by a large number of racial groups. Numerous influences of settlers and invaders have come from India and other neighboring countries to settle, and thus contributed to its culture and ethnic variety. Muslim kings ruled the country as a province of the Indian subcontinent from the early thirteenth century until the eighteenth century, when the British took over (3). Dutch and French trading companies as well as the British East India Company also visited to trade.

With India's independence from the British in 1947, Bengal was partitioned into two parts and the largely Muslim east was included into Pakistan and became known as East Pakistan **(3).** After twenty-four years of Pakistani rule, Bangladesh finally became an independent country in 1971, following a much wounded war known as the Liberation War.

Since its independence, Bangladesh has tried to rebuild itself despite its long experience of violence and damage of war. However, its high population density, recurrent natural disasters and political instability have made the task difficult. Thus, Bangladesh still remains one of the poorest countries in the world.

1.1.4 People

According to the last national survey, conducted in March 2011, the population of Bangladesh was about 160 million and it is the 8th most populous nation in the world, with a population density of 900 per square kilometers (4). Although the dramatic decrease in the country's population growth rate from 3 to 1.5 percent in the past ten years; it still remains one of the most densely populated countries in the world **(4).**

The majority of the population is poor and relatively young; 60% being 25 or younger and 3% being 63 or older. Life expectancy at birth is 70 years for both males and females in 2012 **(4).** The literacy rate is low, with only about 56.8 per cent of the population over fifteen years of age being able to read and write. Adult male literacy is 61.3 percent and female literacy is particularly low at 52.2 percent **(4).** In Bangladesh, education system is categories in the following steps:

Primary Level	1-5 year
Secondary Level	6-10 year
Higher Secondary Level	11-12 year
Higher Study	
• Graduation (pass course)	13-14 year
• Graduation (honours)	13-15 year or more
• Post-graduation	15/16 year or more

Seventy-two percent of the total populations live in rural areas, even though during recent years there has been a large migration from rural to urban areas. The society is characterized by a notable degree of ethnic homogeneity, with over 98 per cent of the population sharing a common language which is Bangla and English is used in urban centers. Of the total population, about 90 per cent are Muslims, 9 per cent Hindus, 1 per cent Buddhists and Christians **(4).** Table 2 shows the overall overview of Bangladesh **(5).**

Table 1.1: Country profile- Bangladesh (5)	
Total Population	161 million (July 2012 est.)
0-14 y	34.3% (male 27 /26 million)
Under 5 years	19 million
Low Birth Weight (LBW)	22%
Under 5 years underweight (u/r)	33%/43%
Urban/ Rural	28/72%
Population growth rate	1.579% (2012 est)
Birth rate	22.53 births/ 1000
Infant mortality rate	48.99 deaths/1000 live birth
Under 5 yrs mortality	52 deaths/1000 live birth
Child education	80% students enrolled in grade one completed primary school Only 46% of boys and 53% of girls attend secondary school
Child labor	13% (male 18 /female-8)
Birth registration (urban/ rural)	13/9%
Total expenditure on health care/capita	48 USD
Total expenditure on health as % of GDP	3.4%

1.1.5 Economy

Bangladesh has made significant strides in its economic sector performance since independence in 1971. The economy has been growing 5-6% per year since 1999 despite political instability, poor infrastructure, insufficient power supplies, and slow implementation of economic reforms. The average per capita income is about US $1046 in 2013. Bangladesh is an agrarian country, 18.4 per cent of the country's GDP is accumulated from production related to agriculture. This sector provides employment of 45 per cent of Bangladeshi workforce **(6).** The main agriculture cash crop is rice, although wheat, potatoes, jute, oil seeds, pulses, tea, sugar cane and tobacco are the principal cash crops. Vegetables, spices and fruits are also produced. Efforts to increase and diversify food production are progressing; however, conventional farming methods, frequent natural disasters and an increasing population keep continual difficulty on food production.

The industrial sector, which contributes around 28.6 per cent of the GDP, is dominated by garment, textile and jute factories **(6).** Sugar, shrimp processing, paper and newsprint, fertilizers, tanneries, cement, ceramic, shipbuilding and pharmaceutical are other rising industries. The country has very limited mineral wealth except for reserves of natural gas, widely used for power generation, urea production, domestic and other industrial purposes **(6).** Capital goods, chemicals, iron and steel, textiles, food, and petroleum products are the major imports. Western Europe, the United States, India, and China are the main trading partners.
Currency: Bangladeshi Taka (BDT); BDT 1 = 100 paisa. Average exchange rate in 2012: BDT 80: USD 1.

1.1.6 Life style and physical activity

Life style of people differs markedly according to rural and urban residences in Bangladesh. Women in the rural area have to do different kind of manual works during their daily activities even inside the house. Cleaning of house, cooking, washing, taking care of children, taking care of cattle, gardening etc. all those requires good physical activities in the rural place. On the other hand, city people are exposed to rather easy way of daily life. But economic condition of the people and social status do also control the way of life of the people. Like the other Asians, Bangladeshi people do not have the tradition of doing extra physical exercise apart from the requirement for their occupation in daily life. Most of the women put lots of their efforts in house hold activities being a housewife after marriage. However there prevails a marked difference in amount of work in household activities between rural and urban set-up and socioeconomic status.

1.1.7 Food habit

South Asians consume a smaller amount of protein and greater quantities of total fat, monounsaturated fatty acids, eggs, dairy products and carbohydrates (about 60–70% of energy intake) compared with Europeans. Bengali food is very similar to that of the rest of the Indian subcontinent. Rice and fish are traditional favorites. With an emphasis on fish, vegetables and lentils served with rice as a staple diet. Their inherent taste for a spicy, sweet or salty food often restrains them to take less cooked vegetables and salad. Frying was commonly used for food preparation method and vegetable ghee commonly used for cooking in Bangladesh, contains trans-fatty acid levels as high as 50%. Similar to other countries of south Asia sleeping after lunch and immediately after late dinner is also a very common tradition in Bangladesh.

1.1.8 Healthcare Service

The poor health conditions in Bangladesh are attributed to the lack of healthcare and services provision by the government. The Ministry of Health and Family Planning was responsible for developing, coordinating, and implementing the national health and mother-and-child health care programs. Less than 40 percent of the population has access to the basic health care services. The total expenditure on healthcare as a percentage of their GDP was only 3.4% in 2009 **(5).** The number of hospital beds per 10,000 populations is 4. Most important thing is that the citizens of this country pay most of their health care bills as the out-of-pocket expenditure **(6).** Immunization and family planning programs have been successful but Bangladesh is still the world's most densely populated country. Improving health care in Bangladesh will be an enormous task. Table 1.2 is showing the Health Workforce in Bangladesh in 2010.

Table 1.2: Health Workforce in Bangladesh in 2010 (6)

	Total number	Density/ 10000 population
Physicians	43315	3.0
Nurses & Midwifery personnel	39992	2.7
Public health workers	6091	0.4
Community health workers	48692	3.3

1.1.9 Urbanization

Like many other developing countries, fast urbanization is also big problem in Bangladesh. Increasing landlessness, narrow scope of business and unemployment in rural Bangladesh are principle reasons for urban migration. Riverbank erosion has also led to urban migration. Dhaka city alone is having 2-3 million such impoverished people. In 1961, only about five per cent of the total population lived in the urban areas. While into 1991 census reported that about 21 per cent of the country's population was residing in urban areas **(4).** At the present time about 28 percent people are living in urban areas **(4).** The rapid increase of the number of urban centers of the minimum size category took place between 1974 and 1981. The explanation behind this growth may be attributed partly to the increase of a large number of growth centers by the government of the recently independent country. About 27 per cent of the total urban populations of the country live in Dhaka, the capital and the largest metropolitan city in the country. It is the 9th largest city in the world and also 28th among the most densely populated cities in the world. In 2008, population in Dhaka was estimated as 12.8 million whereas the number increased to about 25 million by the year 2025 **(5).**

In addition to the adverse effects, urbanization has also served to underline the gap between social classes by reinforcing social inequalities. Although certain aspects of urbanization have been regarded as advantageous, the ultimate benefit has been restricted to certain social groups. For example, whereas urbanization has enhanced access to service and education for middle and upper social classes, poor urban dwellers are becoming poorer. Besides, they are deprived of essential human necessities, such as food and education, and they still suffer from poor health status and bear an enormous disease burden.

1.1.10 Urbanization and Chronic Diseases in Bangladesh

Every country that experienced urbanization and industrialization is witnessed with a transformation of disease pattern from infectious to non-communicable and chronic diseases. During the last three decades Bangladesh experienced a decrease in mortality and fertility rates and an increase in life expectancy. At the same time the country has also faced epidemiologic transition, expanding industrialization, rising income, improved primary health care services, universal immunization and increased knowledge and use of oral dehydration therapy (ORS) resulting in increased life expectancy at birth longer than 70 years. But changing in life styles, eating habits, sedentary life, increased use of tobacco and degrading environmental conditions are likely to develop non-communicable diseases (NCDs). Mainly cardiometabolic disorders, diabetes mellitus (T2DM), hypertension (HTN) and coronary heart diseases (CHD) are increasing. In terms of the number of lives lost due to ill-health and disability, NCDs account for 62% of the total disease burden in Bangladesh **(5).** The under-privileged communities in the country are bearing the heaviest toll of this burden. Figure 1.2 shows the burden of chronic disease in Bangladesh.

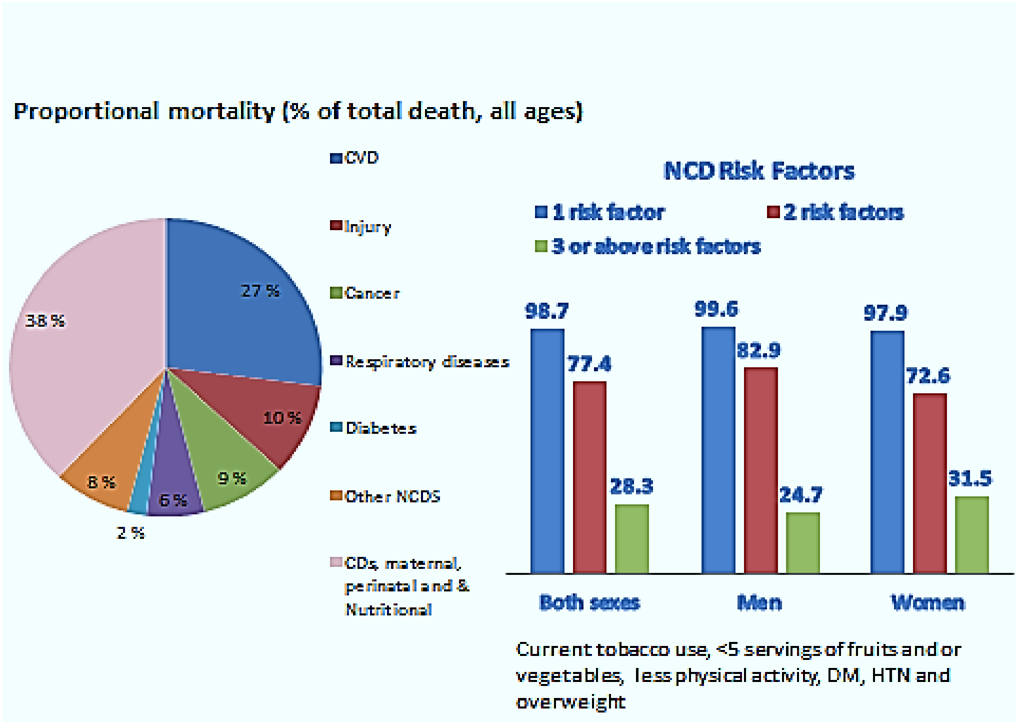

Figure 1.2: Burden of chronic disease – Bangladesh' 2010 (WHO) (6)

In response to the growing burden of NCDs, the Bangladesh government and non-government organizations have taken several steps to implement appropriate programs, but there are still many areas where they could enhance or strengthen their efforts. The Health, Nutrition, Population Sector Programme (HNPSP) has identified three NCDs- cancer, cardiovascular diseases and diabetes mellitus- as major public health problems. Therefore surveillance of these diseases should be started to assist in formulating country policies and programmes. Diabetic Association of Banglaeh has initiated surveillance of diabetes mellitus all over the country through it central and affiliated associations **(7).**

1.2 Burden of Obesity

1.2.1 Burden of Obesity: Global overview

Overweight and obesity are important clinical and public health burdens worldwide. Over the last few decades, there has been an alarming upward trend in the prevalence of obesity both in developed and developing countries **(8, 9).** World Health Organization (WHO) has already recognized the magnitude of overweight and obesity as a global public health problem **(10, 11).** In its 2002 World Health Report, the WHO ranked obesity among the top 10 risks to human health worldwide **(12).** The latest WHO projections indicate that at least one in three of the world's adult population is overweight and almost one in 10 is obese. Additionally there are over 20 million children under age five who are overweight **(13).**

In 2008, more than 1.5 billion adults, 20 and older, were overweight. Of these over 200 million men and nearly 300 million women were obese **(14).** In recent years, there has been increasing recognition that developing countries that still have a substantial problem of undernutrition are now facing an epidemic of both obesity and undernutrition. The highest rate of obesity in Asia is in Thailand, where 6.8% of adults are reported to be obese **(15).** The lowest obesity rates in the region are in the less developed parts of Asia: 2.2% in India and 3.3% in the Philippines **(16, 17).** Growth in population size, population aging, urbanization and changes in lifestyle including increases in total calorie intake and reductions in physical activity, all contribute to an epidemic of overweight and obesity in developing regions **(18).**

Worldwide, Indo-Asian people are among the populations at highest risk for cardiovascular disease and its risk factors including T2DM, HTN, dyslipidemia and metabolic syndrome **(19).** Evidence also suggests that associations between body mass index (BMI), percentage of body fat and chronic diseases may differ between Indo-Asian and Caucasian populations **(20, 21).**

Obesity is also the leading preventable causes of death worldwide. In the United States obesity is estimated to cause 0.1 to 0.4 million deaths per year **(22),** while 1 million (7.7%) of deaths in Europe are attributed to excess weight **(23, 24).** On average, obesity reduces life expectancy by six to seven years, a BMI of 30–35 kg/m^2 reduces life expectancy by two to four years, while severe obesity (BMI > 40 kg/m^2) reduces life expectancy by ten years **(25).**

1.2.2 Burden of obesity in Bangladesh

Population-based data on the prevalence of obesity and its association with cardiometabolic risk factors in Bangladeshi adults have been lacking until recently. In 2010, WHO estimated the prevalence of over-weight/obesity (BMI ≥25kg/m^2) aged over 15 was 8.4% in Bangladesh **(26).** In another study assessed the prevalence of overweight and obesity among women of reproductive age in South Asia between 1996-2006 also reported increase trends of prevalence. Overweight/obesity prevalence increased from 2.7% to 8.9% in Bangladesh; from 1.6% to 10.1% in Nepal; and 10.6% to 14.8% in India **(27).** According to Bangladesh Demographic Health Survey (BDHS) in 2004, prevalence of overweight among urban poor women and rural women were 9.1% and 5.5% respectively. In addition, from 1996/97 to 2004, the proportion of women with at-risk BMI (≥23) increased from 5.1 to 10.2% in rural areas and 24 to 26% in urban areas **(28).**

1.3 Overview of obesity

1.3.1 Definition and Risk Factors of Obesity

Obesity is a medical condition in which excess body fat has accumulated to the extent that it may have an adverse effect on health, leading to reduced life expectancy and/or increased health problems **(29).**

Obesity is most commonly caused by a combination of excessive food energy intake and lack of physical activity, although a few cases are caused primarily by genes, endocrine disorders, medications or psychiatric illness. The determinants can be classified as modifiable and non-modifiable (Table 1.3).

Table 1.3: Modifiable and non- modifiable risk factors of obesity

Modifiable risk factors	Non-modifiable risk factors
Dietary factors	Age
Physical inactivity (sedentary life style)	Gender
Socioeconomic status	Family history
Psycho social factors	Ethnicity
Cessation of Smoking	Genetic factors
Endocrine factors	
Oral contraceptive and other drugs	

1.3.2 Anthropometric indicators and Classification of Obesity

BMI as a measure of general obesity, and WC and WHR as measures of central obesity, have been proposed to define obesity **(30).** The most common measure that has been used is the BMI. BMI is calculated as the weight in kilograms divided by the square of the height in meter (kg/m^2) and its concept dates back to 1869 as Quetelet's index **(31),** which was shown as a fairly good indicator of general fatness **(30,32,33)**. However, despite its use in epidemiological and clinical studies, for a given BMI, the adiposity varies by age, gender and ethnicity **(34).** Asian populations generally have a lower body mass index (BMI) than many other ethnic groups, but the association between BMI and glucose intolerance is as strong as in any other population **(35).**

Since the early 1980s, WHR has been considered more closely correlated with abdominal visceral fat than the BMI and a better predictor of CVD or diabetes incidence than the BMI **(36 - 39).** Since the 1990s, interest in WC has increased because it correlates more closely with abdominal visceral fat than either the WHR or BMI **(40-42)** for identification of cardiometabolic risk factors.

The central obesity can be divided into two types in terms of fat distribution and the risk of development of the disease. The gynoid type of fat distribution is common in women, where a pear shaped indicates heavier deposition of fat around the thighs and buttocks. Individual with this type of distribution typically do not develop impaired glucose metabolism. In contrast, the android type of fat distribution (apple shape) is more typical of men and features fat deposits around the waist and upper abdomen. This pattern is associated with significant risk of HTN, cardiovascular diseases and T2DM.

The use of different anthropometric measures has been proposed by various organizations to classify overweight and obesity in adults (Table 1.4)

Table 1.4: Classification of overweight and obesity by different international organisation

	BMI (kg/m^2)		WC (cm)			WHR	
	WHO (Global) **(32)**	WHO (Asian) **(33)**	WHO **(43)**	NCEP **(44)**	IDF* **(45)**	WHO **(32)**	IDF* **(45)**
Underweight	<18.5	<18.5					
Normal weight	18.5 – 24.9	18.5 – 22.9					
Overweight	25 – 29.9	23 – 24.9					
Obese	≥ 30	≥ 25	≥ 94/80 Men/Women	>102/88 Men/ Women	≥ 94/80 or ≥ 90/80 Men/ Women	≥ 1.0/0.85 Men/Women	≥0.94/0.80 or ≥0.90/0.80 Men/Women

WHO: World Health Organisation; NCEP: National Cholesterol Education Program; IDF: International Diabetes Federation; BMI: body mass index; WC: waist circumference; WHR: waist hip ratio. *WC of ≥ 94/80 cm in men and women for European, Eastern Mediterranean, Middle East and Sub-Saharan African and ≥90/80 cm for Chinese, South Asians and South and Central American men/women, respectively.

The WHO definition classified individuals into different stages of obesity using BMI **(32)** while the National Cholesterol Education Program (NCEP) **(33)** and IDF classified individuals as obese and non-obese, using ethnic-specific WC with purpose to define the metabolic syndrome **(45).** Despite lower BMI, some Asian countries have similar or even higher prevalence of cardiometabolic diseases than Western countries. The concept of different cut-offs for BMI, WC and WHR for Asian populations have been proposed by the WHO and IDF.

1.3.3 Health Hazards of Obesity

Not just a cosmetic problem, obesity is also a positive risk factor in the development of T2DM, HTN, gall bladder disease, CHD and certain type of cancers (colorectal, hepatic, renal), especially hormone related (endometrial, ovarian, cervical, breast, prostate) ones. There are in addition, several associated diseases, which although not usually fatal, cause great deal of morbidity in the community. These are varicose veins, abdominal hernia, osteoarthritis of knees, hips and lumbar spine, hyperuricemia and gout, sleep apnea, flat feet and psychosocial stresses particularly during adolescence. Abdominal obesity is important in the development of insulin resistance and metabolic syndrome (hyperinsulinaemia, dyslipidemia, glucose intolerance and HTN).

Figure 1.3: Obesity Health Risks

1.4 Health Hazards of Obesity: Diabetes

1.4.1 Overview of Diabetes

Diabetes mellitus is a chronic metabolic disease characterized by elevated blood glucose levels resulting from the body's inability to produce enough insulin or depleted insulin action, or both. The chronic hyperglycemia in diabetes is associated with long-term damage, dysfunction, and failure of various organs, especially the eyes, kidneys, nerves, heart, and blood vessels **(46).**

There are four main forms of diabetes:

Type 1 diabetes (formerly known as insulin dependent): Type 1 diabetes is the predominant form of the disease in younger age groups, mostly in high income countries, especially in the Nordic Countries. However, evidence suggests that T1DM is also increasing both in rich and poor countries.

Type 2 diabetes (formerly named non-insulin dependent): Type 2 diabetes is much more common and accounts about 85 to 95% of all diabetes cases worldwide. Once considered a disease of the affluence, T2DM is now a global health priority. It is in fact one of the major contemporary causes of premature disability and death. In virtually every developed nation, diabetes ranks as one of the top two causes of blindness, renal failure, and lower limb amputation. The life expectancy of individuals with T2DM may be shortened by as much as 15 years, with up to 80% dying of cardiovascular disease. The most dramatic increases in T2DM have occurred in populations where there have been rapid and major lifestyle changes. These include changes in diet, and reductions in physical activity, with consequent increases in the prevalence of overweight and obesity.

Gestational diabetes mellitus (GDM): any degree of glucose intolerance with onset or first recognition during pregnancy **(47).** Gestational diabetes develops in 2-5% of all pregnancies, but usually disappears when the pregnancy is over. Women with GDM are likely to develop IGT and T2DM in the postnatal period **(48)** or later life **(49-51),** and children born from a pregnancy complicated by GDM are also at risk of childhood obesity and abnormal glucose metabolism **(52, 53).**

Other specific types of diabetes due to other causes, e.g., genetic defects in β-cell function, genetic defects in insulin action, diseases of the exocrine pancreas (such as cystic fibrosis), and drug- or chemical-induced (such as in the treatment of HIV/AIDS or after organ transplantation).

1.4.2 Global burden of diabetes

DM has already become a worldwide epidemic. The public health burden of DM is growing rapidly worldwide. Not only its current prevalence but also the increase of its incidence in the near future will create a global health problem. On 20 December 2006, the UN General Assembly passed a resolution (61/225) and declared 14 November as the World Diabetes Day **(54).** This landmark Resolution recognizes DM as a chronic, debilitating and costly disease associated with major complications that pose severe risks for families, countries and the entire world.

The International Diabetes Federation (IDF) has predicted that the number of individuals with DM will increase from 366 million (8.3%) in 2011 to 552 million (9.9%) in 2030, with 80% of the disease burden in low and middle-income countries (LMCs). The overall total predicted increase in numbers with DM from 2011 to 2030 is 50.7%, at an average annual growth of 2.7%, which is 1.7 times the annual growth of the total world adult population. Forty-eight percent of the anticipated absolute global increase of 186 million people with DM is projected to occur in India and China alone **(55).**

1.4.3 Burden of DM in Bangladesh

Bangladesh is an agro-based rural country where a vast majority (72%) of the population lives in rural areas **(56).** Like other developing countries Bangladesh has undergone marked economic and epidemiologic transition in recent years. Increasing urbanization has been found with a sedentary lifestyle, higher calorie food intake and stressful condition, which might have contributed to the increasing prevalence of DM **(57, 58)** and which are now recognized as major public health problem in a resource constraint country like Bangladesh**.** Overall, the health care costs among the DM population in Bangladesh are over 118 million USD per year.

In 2011, the IDF estimated that 8.4 million people living in Bangladesh had diabetes and in which more than 96 percent reported T2DM. By 2030, that number is expected to grow to 16.8 million. This explosion in diabetes prevalence will place Bangladesh among the top five countries (Table 1.5) in terms of the number of people living with diabetes in 2030 **(55).** It has been reported that prevalence of T2DM is more in urban people compare to rural people in Bangladesh and onset at a relatively young age and low body mass index (BMI) **(59, 60).**

Table 1.5 – Top 10 countries for numbers of people aged 20-79 years with diabetes mellitus (DM) in 2011 and 2030 (55)

2011		2030	
Country	Millions	Country	Millions
China	90.0	China	129.7
India	61.3	India	101.2
USA	23.7	USA	29.6
Russian Federation	12.6	Brazil	19.6
Brazil	12.4	Bangladesh	16.8
Japan	10.7	Mexico	16.4
Mexico	10.3	Russian Federation	14.1
Bangladesh	8.4	Egypt	12.4
Egypt	7.3	Indonesia	11.8
Indonesia	7.3	Pakistan	11.4

1.5 Literature Review

1.5.1 Adult prevalence and risk factors for obesity

Generally, most of the populations experienced an increase in the prevalence of obesity in the last decade, most likely due to lifestyle changes associated with urbanization, westernization and economic development. Similarly the increase in prevalence of obesity was reported in all populations in the WHO MONICA study between the 1980s and 1990s, due to increased energy supply **(61).** In recent years, there has been increasing recognition that developing countries that still have a substantial problem of undernutrition are now facing an epidemic of both obesity and undernutrition **(18).** The prevalence of obesity ranged from 0.3 -3.4% in Asian Indians, Filipinos, Japanese and Chinese **(62)** to 4.7 - 9.1% in Thais **(63),** Hong Kong Chinese **(62)** and Singaporeans **(64).** The prevalence was between 6.0% and 9.3% in men and 12.0% and 25.0% in women from Africa **(65),** Mauritius (**66**), Brazil **(67)** and Mongolia **(68).** The prevalence of obesity ranged from 10.0 - 15.5% in the Netherlands, Spain (DORICA) and Sweden **(69-71)** to 19.3 - 27.7 % in Finland **(72),** Spain **(73),** Australia **(74),** Canada **(75),** the UK **(76),** Italy **(77)** and Mexico **(78),** with similar rates in men and women. In the USA, the prevalence of obesity was over 32.0%, with higher rates in Mexican Americans and Blacks than in Whites **(79).** The increasing trend in prevalence of obesity was observed in most of the populations, with a few exceptions; in India, Mongolia and the USA the prevalence did not increase in the last decade. The prevalence was doubled in Brazil, China and Thailand.

Genes, age and female sex (in Central and Eastern Europe, Latin America, Asia and Africa), all have been considered as nonmodifiable risk factors for obesity. In 2007, Fat Mass and Obesity (FTO) gene variants predisposed individuals to T2DM through their effect on BMI in the European population **(80).** The findings were further confirmed in Chinese **(81),** Japanese **(82),** Asian Indians **(83)** and Hispanic and African Americans **(84).** Obesity increases with age in both gender, especially in women **(69, 76, 79)** with a peak prevalence at 50 - 60 years in developed and 40-50 years in developing countries **(85).** Individuals, particularly women with low socioeconomic status (SES), were more obese in highly developed countries mostly **(86)** but women with high SES were more obese in low- and medium-development regions, such as in Africa **(86)** and India **(87).**

1.5.2 Obesity as a major risk factor for T2DM

Obesity is one of the major modifiable risk factor for T2DM, HTN and many other chronic diseases. Longitudinal studies have shown obesity to be a powerful predictor of T2DM development **(88, 89).** Furthermore, interventions directed at reducing obesity also reduce the incidence of T2DM. Several studies indicate that WC or WHR, which reflect visceral (abdominal) fat, may be better indicators of the risk of developing T2DM than BMI **(39, 90).** Thus an appropriate definition of obesity, underline causes of obesity and its predictive value in relation to T2DM is necessary in intervention strategies in different populations.

Obese women were at higher risk of developing T2DM during a 14-year follow-up, 5-fold in the BMI group of 24.0 - 24.9 kg/m^2, 40-fold in 31.0 - 32.9 kg/m^2 and 93-fold in the 35.0 kg/m^2 category, compared with the group with BMI of <22.0 kg/m^2 in the large Nurse's Health Study **(91)** as well as in the Male Health Professionals in the USA **(92)** during a 7-year follow-up. A 20-year follow-up of the Nurse's Health Study further confirmed that weight increase as a major risk factor for T2DM in all, particularly in Asians **(93),** which was in agreement with findings from others **(94).** Prospective studies have reported a strong association between daily physical activity and reduced risk for developing diabetes, with a relative risk reduction of 15 - 60% **(95, 96).** Furthermore, clinical intervention trials have clearly shown that weight reduction with healthy diet and physical activity can prevent or at least delay the onset of T2DM in individuals with impaired glucose tolerance in Swedish **(97),** Chinese **(98),** Finnish **(99),** American **(100),** Asian Indians **(101)** and Japanese subjects **(102).** The relative risk reduction for diabetes ranged from 28% in Asian Indians to 67% in Japanese during the intensive intervention period. This suggests that weight reduction with a healthy lifestyle is the cornerstone in prevention of obesity related conditions such as diabetes.

1.5.3 Comparison of General and Central obesity for Predicting T2DM

In the recent years, there has been increasing speculation over which measure of overweight and obesity is best able to discriminate those individuals who are at increased cardiometabolic risk. Epidemiological studies have shown overweight and obesity as an independent risk factor of T2DM, HTN, dyslipidaemia and CVD **(103, 104).** BMI is often used to reflect total body fat amounts, whereas the WC and WHR are used as surrogates for intra-abdominal adiposity **(40, 105-107).** Central obesity, which suggests excessive deposition of intra-abdominal fat, is also found to be an important predictor of cardiometabolic risk. Furthermore, central obesity is assumed to play a pivotal role in the development of the 'metabolic syndrome' (MS), a term given to the clustering of CVD risk factors **(108).**

A number of epidemiological studies and meta-analyses of the comparison between different anthropometric indices (BMI, WC and WHR) for assessing T2DM and other cardiometabolic risk factors have been carried out in different ethnic groups since 1990. Lee et al. **(109)** conducted a meta-analysis involving 10 studies (nine of which were cross-sectional) and over 88 000 individuals, to determine which of the indices (BMI, WC and WHR) has the best discriminator of major cardiovascular risk factors are: HTN, T2DM and dyslipidemias. In both men and women, measures of central obesity were superior to BMI as discriminators of cardiovascular risk factors, although the differences were small and unlikely to be of clinical relevance. Further, the study showed that combining BMI with any measure of central obesity did not improve the discriminatory capability of the individual measures.

A meta-analysis of 35 cohort studies that examined the association between different anthropometric measures of obesity and incident diabetes has shown that the pooled relative risk for diabetes incidence did not differ significantly between BMI and WC or WHR **(110).** WC (not for Asian men) and WHR were more strongly associated with prevalent diabetes than with BMI in Asian and Caucasian women, but these measures did not differ in Caucasian men in the Obesity in Asia Collaboration study (OAC) **(111).** A recently published review article including 17 prospective and 35 cross-sectional studies that compared the performance of anthropometric measures with DM **(112)** were found inconsistent. For prospective studies, WC showed higher association in Mexican Americans and African Americans but higher BMI in Pima Indians.

Among cross-sectional studies that have formally tested the differences, most showed a slightly higher odds ratio (OR) or larger area under the receiver-operating characteristics (ROC) curve for WC than for BMI. All studies included in the review showed that either BMI or WC (or WHR) predicted or was associated with T2DM independently, regardless of the controversial findings on which of these obesity indicators is better **(112).** The observations from INTERHEART study indicate that WHR shows strongest association with cardiovascular risk compared with BMI or WC across 52 populations from every continent **(113).** Based on prospective and cross-sectional studies, BMI, WC and WHR have each been identified as an independent risk factor for DM in the Bangladeshi populations studied. Previous reports have also shown that central obesity is a stronger predictor of the development of T2DM and other cardiometabolic risk indicators including HTN, dyslipidemia and MS in Bangladeshi study subjects **(59, 114- 116)** which is consistent with the findings of others South Asian countries **(117).**

1.5.4 Optimal Cut-off Point for Anthropometric Indices for Predicting T2DM

Although there are several instruments to measure total body fat and its distribution, there is still no ideal method for the measurement of adiposity (diagnostic definitions) or cut-off points that should satisfy the criteria of being accurate, precise, accessible and acceptable worldwide. The concept of different cut-offs for different ethnic groups have been proposed by the WHO **(32, 33),** because some ethnic groups have higher cardiovascular and metabolic risks at lower BMI. Currently, different definitions for obesity, using WC has been proposed by different organizations in various populations. Central obesity, using ethnic-specific WC values, is used with the purpose to define the MS. In addition, the recommended cut-off values for WC and BMI for detecting diabetes differ among ethnic groups **(30-34, 43-45),** with lower values for Asians and higher for Europeans. However, the comparability of the cut-off values is limited within populations of the same ethnicity which may be due to variation in age range of the study participants or to the methods applied to determine the optimal cut-off values in different studies. All studies aiming to choose BMI and WC cut-off values almost exclusively used the ROC curve approach, in which the sum of the sensitivity and specificity was maximized, but choosing the WC values using this approach was considered inappropriate

(118). Qiao and Nyamdorj et al **(119)** review (based on 4 prospective and 24 cross-sectional studies) has also shown the marked variation in cut-off values between ethnic groups. Tongans had the highest BMI and WC optimal cut-off values (not for WHR), followed by studies in the USA and the UK. The BMI and WC cut-off values were higher for ethnicities in the USA and the UK studies than in their counterparts in their original countries. The optimal cutoff values for BMI were 27 - 28 kg/m^2 in White men and women (Australia, Germany, France (men only), the UK and the USA) but were 30 kg/m^2 for men in the NHANES III and 25 kg/m^2 for women from France. The optimal WC (WHR) cutoff values were 97 - 99 cm (0.95) for white men and 85 cm (0.83 - 0.85) for white women living outside the USA and the UK. The values for BMI were 23 - 24 kg/m^2 in Chinese, Japanese, and Thai men and 22 - 23 kg/m^2 in Indians. The optimal cut-off values for WC were 85 cm (0.90) for Chinese, Japanese, Indian, and Thai men and 75 - 80 cm (0.79 - 0.85) for women in these ethnic groups from Asia; the values for other ethnic groups were between those for Whites and Asians. White, Chinese, Japanese, Indian and Bangladeshi men had higher values than women of these ethnicities, but Thai, Iranian, Iraqi, Tunisian, Mexican, African and Tongan men did not.

Chapter 2: Rationale, Research Questions and Objectives

2.1 Rationale

Over the last few decades, there has been an alarming upward trend in the prevalence of obesity both in developed and developing countries **(8, 9).** World Health Organization (WHO) has already recognized the magnitude of overweight and obesity as a global public health problem **(10, 11).** The latest WHO projections indicate that at least one in three of the world's adult population is overweight and almost one in 10 is obese. Additionally there are over 20 million children under age five who are overweight **(13).** Population-based data on the prevalence of obesity and its association with cardiometabolic risk factors in Bangladeshi adults based on newly proposed cut-off level for Asian population have been lacking until recently.

Epidemiological studies have shown overweight and obesity as an independent risk factor for T2DM **(103, 104).** Central obesity, which suggests excessive deposition of intra-abdominal fat, is also found to be an important predictor of cardiometabolic risk. Commonly used anthropometric indicators such as BMI, WC and WHR have been proposed to define obesity in epidemiological studies. However, there is controversy regarding which of these anthropometric indicators best defines obesity and conveys the highest risk for T2DM and other cardiometabolic risks **(120-122).** Furthermore, the International Association for the Study of Obesity and the International Obesity Task Force have suggested lower BMI cutoff values for the definitions of overweight (23.0–24.9 kg/m^2) and obesity (25.0 kg/m^2 or greater) in Asian populations **(107, 33)** because of the observed differences between populations. However, there are few reports and only small studies in the south Asian region based on these cut-off values. Further, it is not known whether the revised definition of obesity would be valid at a population level in terms of being better associated with the consequences of obesity in these populations. In the above context, we sought to determine the prevalence of overweight and obesity using the Asian-specific definition in a rural Bangladeshi population. We also studied factors associated with being overweight or obese in rural Bangladeshi population. It should be noted that Bangladesh is an agro based rural country where a vast majority (72%) of the national population lives in rural areas, it is important to collect data on the prevalence of obesity and its co-morbidities there **(4).**

2.2 Hypothesis:

2.2.1. There is high prevalence of general and central obesity in rural areas in Bangladesh**.**

2.2.2 Obesity is a risk indicator of diabetes in rural Bangladeshi population.

2.3 Research questions:

2.3.1 What is the prevalence of general and central obesity in rural Bangladeshi population?

2.3.2 Is there any association between obesity and diabetes in rural Bangladeshi population?

2.4 Objective:

2.4.1 Primary objective:

- To determine the prevalence of general and central obesity in rural Bangladeshi population based on newly proposed cut-off level for Asian population.

2.4.2 Secondary objectives:

- To determine the associated risk indicators for general and central obesity in rural Bangladeshi population.
- To observe the association between obesity and diabetes in rural Bangladeshi population.

Chapter 3: Research Methodology

3.1 Study design and study site:

The study was a population-based cross-sectional study which had been conducted in a rural community called Chandra, 40 km. north of Bangladesh's capital, Dhaka in 2009. The survey was carried out in two phases. The first phase consisted of household census of the total population residing in the study locations. Based on the census results, a list of all men and women aged 20 years and above was selected in the second phase. Required numbers of individuals were selected following a random procedure.

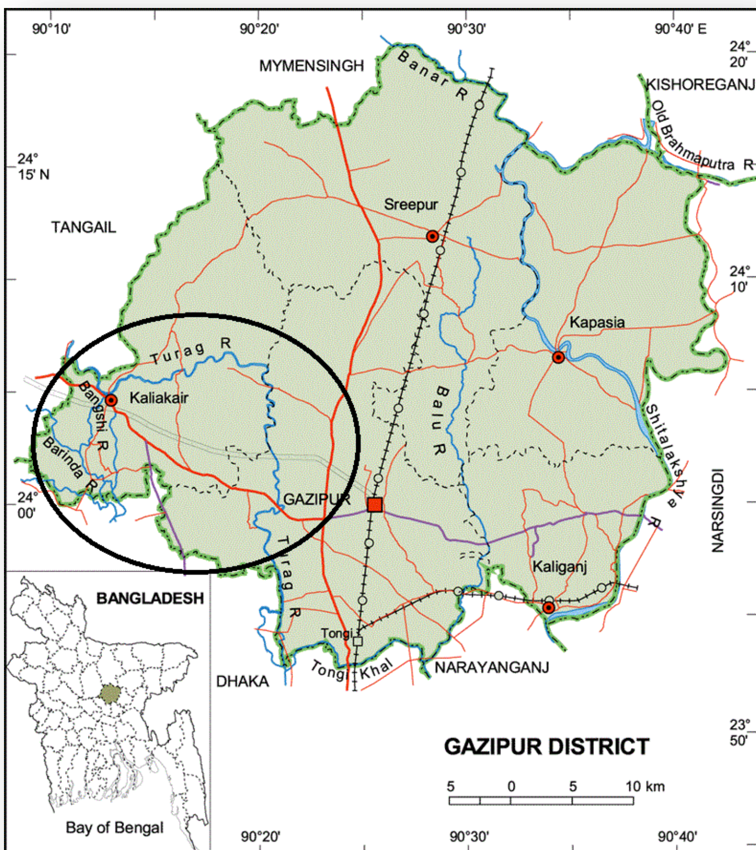

Figure 3.1: Study site- Chandra, Gazipur

3.2. Study period:

March 2009 to December 2009.

3.3. Study population:

Chandra Rural Study was carried out in twenty-five villages of ‘‘Gazipur” district during March to December’ 2009. The area is approximately 40 km north of capital Dhaka city. Ten villages were randomly selected from those twenty-five villages with a population of approximately 20,000 aged ≥20 years. For this study, 3,000 individuals were randomly selected and among them 2,376 (79.2%) participated. The present analysis is based on 2,293 participants (842 male and 1,451female) for whom all the variables were available. The demographic and social characteristic profile of the general population of Chandra was described as rural, without urban facilities. The main livelihood of the population was agricultural and other agrarian activities.

3.4. Inclusion criteria:

Age: ≥20 years, Sex: both sexes, willing to participate and able to communicate.

3.5. Exclusion Criteria:

Pregnant women, and self-reported or medical-recorded history of myocardial infarction, renal disease, liver disease, tuberculosis, malignant diseases and any severe infection at the time of screening.

3.6. Sample size of primary study: In 2009 study, 3000 randomly selected individuals were invited to participate in the study and among them 2376 (79.2%) participated.

3.7. Study variables:

3.7.1. Socio-demographic variables: age, sex, economic status, education status, smoking habit, physical activity, dietary habit

3.7.2. Anthropometric variables: height, weight, body mass index (BMI), waist circumferences (WC), waist height ratio (WHR)

3.7.3. Clinical and Biochemical variables: Systolic blood pressure (SBP), diastolic blood pressure (DBP), hypertension (HTN), fasting plasma glucose (FPG), 2 hour plasma glucose, total cholesterol (T-Chol), impaired fasting glucose (IFG), impaired glucose tolerance (IGT), diabetes (T2DM), triglyceride (TG), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C)

3.8. Data collection:

Data were taken from the 2009 Chandra Rural Study - a joint research initiative of Diabetes Association of Bangladesh and University of Oslo funded by Norwegian Research Council. In 2009, the study was consisted of two phases of data collection. Household census followed by sample survey and collection of other forms of data.

3.8.1. Phase 1: Household census:

At the beginning of the study, community leaders residing in the area were invited to a discussion meeting with the project team leader. They were oriented about the purpose of the study and requested to give their comments about the study. Their co-operation was appreciated in a participatory manner. Each of the community leaders was given specific task. For example, organizing or collecting household list, coordinating with the project field team, and providing feedback to the project team based on their background and interest. Sixteen volunteers were recruited in four teams from the local community and were trained by the project team leader. In addition, four physicians were employed to supervise the project work. Three days of training, both theoretical and practical, for the project workers were conducted prior to the commencement of the study. The study team moved from village to village collecting the required information.

The first phase of census survey was carried out during the months of March to December 2009. Approximately 20,000 inhabitants aged 20 years and above were listed from the 10 selected villages. All individuals were given an identification number including a household number. All men and women aged 20 years and above were considered eligible except pregnant women and subjects, who were unwilling to participate. The eligible participants were informed about the objectives of the study. They were also informed about the site and procedural details of the investigation. After collecting informed consent, each interested individual was requested to attend a specific nearby project site after overnight fasting for at least 12 hours.

3.8.2. Phase 2: Sample survey and collection of other data:

3.8.2.1. Sample survey:

Upon arrival in the field sites, different sets of investigations and physical examinations were done for each of the subjects taking part in the study. At first, an initial blood sample was taken to estimate the fasting plasma glucose (FPG). Then all the subjects were given 75 gram oral glucose to drink and requested to wait for 2-hours for second blood sample collection. During this 2-hour waiting time, they were interviewed for collection of socio-demographic information. After completion of the interview, the anthropometric measurements including height, weight, hip and waist girth were taken. In addition, blood pressure was recorded at this time followed by physical examination to find out whether there was any anemia, jaundice, and enlarged liver or enlarged spleen. After 2 hours, a second blood sample for OGTT was done by glucose analyzer. Details of all the investigations and physical examinations are written below.

3.8.2.2. Anthropometrical measurements

Anthropometric measurements including height, weight, and waist and hip circumferences were taken with the subjects wearing light clothes and without shoes. Weight was recorded to the nearest 0.1 kg using electronic digital LCD weighing machines (Best Deluxe Model; Bathroom, Dhaka, Bangladesh) placed on a flat surface. The scales were placed on a flat surface and calibrated using a standard (20 kg) each day. Height was taken while the subjects stood in erect posture, touching the occiput, back, hip, and heels on a straight measuring wall, while the subjects looked straight ahead. Body mass index was calculated as the weight (Kg) divided by square of the height (m^2). Waist circumference was measured by placing a tape horizontally midway between the lower border of the ribs and upper border of iliac crest on the mid-axillary line. Hip circumference was measured to the nearest centimeter at the greatest protrusion of the buttocks, just below the iliac crest. WHR was then calculated from waist (cm) and hip circumference (cm).

3.8.2.3. Measurement of blood pressure:

Special precaution was taken to reduce the variation of BP value with resting blood pressure; subjects were asked to relax and take rest for 5 minutes in sitting position before measuring the BP. Then the pressure was measured on the right arm using normal cuffs for adult fitted with a standard sphygmomanometer placing the stethoscope bell lightly over the brachial artery. Blood pressure was recorded to the nearest 2 mmHg from the top of the mercury meniscus. Systolic pressure was recorded at the first appearance of sounds, and diastolic pressure was measured at phase V, that is, the disappearance of sounds.

3.8.2.4. Blood glucose estimation:

On arrival at the field center, an 8 ml fasting venous blood sample was taken from each participant for measuring fasting plasma glucose (FPG) and fasting lipids profiles. All participants other than those with known diabetes had a 75 gm oral glucose tolerance test. Each participant was given a 75 gm oral glucose solution (75 gm oral glucose in 250 ml of water) to drink. Another 3 ml of venous blood was collected after 2 hours to determine the 2 hour plasma glucose level (2hPG). Venous plasma blood samples were collected in a tube containing sodium fluoride and potassium oxalate (1:3) and were centrifuged immediately after collection. Separated plasma samples were sent in ice gel packed cooling boxes to the laboratory of Bangladesh Institute of Research and Rehabilitation for Diabetes, Endocrine and Metabolic Disorders (BIRDEM), and stored at -70^{0}C until laboratory assays were completed. Plasma glucose was measured using a glucose oxidase method and the Dimalesion RxL Max (Siemens

AG, Erlangen, Germany) on the same day. Quality control on the blood glucose measurements was checked by measuring the 2 h plasma glucose values using the glucose oxidase method in every tenth sample. The intra-assay coefficient of variation was 1.24% at a mean of 5.86 mmol/l, and the inter-assay coefficient of variation was 2.10% at a mean of 5.23 mmol/l.

3.8.2.5. Fasting blood lipids estimation:

Fasting serum lipid profile was estimated by standard enzymatic procedures (DimalesionRxL Max). HDL-C was estimated by the direct assay method and LDL-C was estimated by Friedewald's formula.

3.8.2.6. Methods and specification of the machines for the various laboratory tests

Test	Sample	Method	Specification of Machine	
			Measurement Type	**Name of the analyser**
OGTT • FPG • 2h AG	Venous Plasma	Glucose oxidase	End point	Dimension RxL Max (Siemens AG, Erlangen, Germany)
T-Chol	Serum	CHOD-PAP	End point	Do
TG	Serum	GPO-PAP	End point	Do
HDL	Serum	Differential Precipitation	End point	Do
LDL	Serum	Friedewald's Formula	End point	Do

3.8.2.7. Food behavior questionnaire:

Food consumption was assessed with the 24-hour recall method. The participants were shown various standardized utensils such as serving plates, cups, spoons and models of different foods to get the nearest possible approximation of serving sizes of the cooked food consumed. The serving weight of different food items was calculated from this information. Equivalent raw food weight was obtained by using a conversion table for Bangladeshi foods developed at the Institute of Nutrition and Food Science (INFS) **(123),** University of Dhaka. A program package, based on Bangladeshi and Indian food composition table **(124,125)** was used to calculate the nutrients from raw weight of edible portion of food.

3.8.2.8. Definition of terms:

Cut off points for general obesity for both sexes were a BMI of ≥25 kg/m^2 **(33),** cut off points for central obesity including WC for men and women were ≥90 and ≥80 cm (45), WHR for men ≥0.90 and women for ≥0.80 **(33, 45, 107)** respectively. DM was defined as FPG ≥7.0 mmol/l and/or 2hPG ≥11.1 mmol/l **(126).** In addition, known diabetes was defined by the use insulin or oral antidiabetic medication(s) and self-reported DM. Individuals were considered to have HTN if their average systolic blood pressure was ≥140 mmHg or diastolic blood pressure was ≥90 mmHg, or if they were receiving treatment for HTN **(127).** Dyslipidemia was defined as serum triglycerides ≥1.70 mmol/L and HDL-C <1.04 mmol/L for men and <1.29 mmol/L for women. Smoking habit was classified as either current or non/ex-smoker and based the monthly expenditure socio-economic condition was classified as low (<6000 Bangladeshi Taka [BDT, 1 USD = 84 BDT]), medium (6000-11000 BDT) and high (>11000 BDT). Education level graded as illiterate: unable to write and read; under graduate: having primary and higher secondary education; graduate. Physical activity was graded on the ordinal scale of 1-3, corresponding to light, moderate and heavy, according to the activity level based on their occupation. For the purpose of data analysis, these results were transformed into a binary variable - inactive (grade 1) and active (grade 2 and 3).

3.9. Statistical analysis:

The present analysis was based on 2,293 participants for whom all data were available. Both STATA 11 for Windows (STATA Co., College Station, TX, USA) and PASW statistics version 18 for Windows (SPSS Inc., Chicago, IL, USA) were used as needed. Means and Percentages with 95% confidence intervals adjusted for age were given for normally distributed continuous variables and categorical variables as needed. Highly skewed variable (TG) was logarithm transformed before analysis and the result was transformed back to the original. Age specific and age standardized prevalence by direct standardization method were estimated on the basis of 2001 census data before performing statistical tests **(128).** Differences between the groups of means and proportions adjusted for age were tested by analysis of covariance (ANCOVA) and logistic regression. Logistic regression analysis was also tested for observing association between obesity indices and diabetes. Multiple logistic regression analyses were also used to study the association of risk variables with general and central obesity. Sensitivity and specificity were examined by the receiver operating characteristic (ROC) analysis (129,130), and the areas under curve (AUC) cut-off values were calculated for each anthropometrical parameter. Statistical inference is based on 95% confidence intervals (CIs) and the significance level was set at 0.05.

3.10 Ethical Consideration

The study was carried out in accordance with the Declaration of Helsinki as revised in 2000 (131). The local leaders of the project areas were invited to a discussion meeting with the project team. They were oriented about the purpose of the study and requested to give their comments about the study. Their comments and suggestions were incorporated into the study design. In addition, to enhance the acceptability of the study, volunteer were recruited from the local people.

Informed verbal consent was obtained from all study subjects. Approximately 72% of the adult population is illiterate in Bangladesh, therefore written consent was not sought in order to avoid selection bias. Prior to enrolment in the study, interviewers read out to each potential respondent a paragraph that described the purpose of the study and sought verbal consent to include them into the study. All respondents were informed that they were free to leave or to refuse to take part in the research at any time. The respondents who did not show interest in being included in the research were not included.

Data collected for this study was stored in a way that separated personal identifiers from all samples collected and the responses to all survey questions. Therefore, it is not possible to identify respondents either directly or through identifiers linked to them.

All patients received a hardcopy of their own biochemical results. In cases of abnormal laboratory test results; every effort was made to refer participants to the appropriate health services. All the participants diagnosed with diabetes were registered free of charge to the nearest diabetic center of DAB and same time, all the pre-diabetes subjects were recruited in diabetes intervention program, a joint diabetes prevention intervention program of DAB and University of Oslo.

All procedures involving for this study were approved by National Committee for Medical and Health Research Ethics (NEM) of Norway and the Ethical Committee of Diabetic Association of Bangladesh for Medical Research.

Chapter 4: Results

4.1 Demographic and socio-economic characteristics of the study population (Table 4.1 and Figure 4.1)

Table 4.1: Demographic and socio-economic characteristics of the study subjects

Variables		Frequency	Mean (95% CI) / Percentage
Age	Total Participants	2293	41.8 (41.2, 42.4)
	Male	842	44.3 (43.3, 45.2)
	Female	1451	40.4 (39.7, 41.1)
Age group (year), %	20-30	548	23.9
	31-40	702	30.6
	41-50	562	24.5
	≥51	481	21.0
Gender, %	Male	842	36.7
	Female	1451	63.3
Education, %	Illiterate	1037	45.2
	Primary (0-5 class)	419	18.3
	Secondary (6-10 class)	627	27.3
	College (>10 class) & above	210	9.2
Occupation, %	Farmer	443	19.3
	Business	199	8.7
	Skill labour	112	4.8
	Manual labour	194	8.5
	Housewives	1345	58.7
Socioeconomic status, %	Low income (<6000 BDT)	953	41.6
	Middle income (6000-11000 BDT)	967	42.2
	High income (>11000 BDT)	373	16.3
Smoking habit, %	Cigarette smoking	365	15.9
Physical activity, %	Active	1946	84.9
	Inactive	347	15.1
Calorie consumption	Total calorie intake (kcal/ day)	2293	1600 (1587-1613)
	Carbohydrate (>55%)	2077	90.6

Protein (≥15%)	754	32.9
Fat (>30%)	196	8.5

The study of demographic and socio-economic characteristics is illustrated in table 4.1. The present analysis is based on 2,293 participants for whom all the variables were available in this cross sectional study. The mean age of the participants was 41.8 (95% CI; 41.2, 42.4) years. The participants were divided into 4 age groups with 10. Between them, 548 (23.9%) participants were between 25 to 30 years, 702 (30.6%) participants were between 31 to 40 years, 562 (24.5%) were between 41 to 50 years and 481(21%) were above the age of 51 years. Among the total number of participants, 36.7% (n=842) were male and 63.3% (n=1451) were female participants. Females were younger as opposed to male subjects. A major portion of the participants were not educated (45.2%). Primary, secondary, college and above level participants were 18.3, 27.3, 9.2% accordingly. A large number of participants were housewives (58.7%). Among the others, there were businessmen of 8.7%, manual labor of 8.5%, farmer of 19.3% and skill labor of 4.8%, respectively. Among them high income participants (>11000 BDT/ month) were 16.3% while, middle (6000-11000 BDT/month) and low income participants (<6000 BDT/month) were 42.2% and 41.6% respectively.

Among the participants 15.9% and 15.1 were cigarette smokers and physically inactive respectively. Mean calorie consumption was 1600 Kcal/day. 90.6, 32.9 and 8.5% participants consumed recommended level of carbohydrate (>55%), protein (≥15%) and fat (>30%) respectively.

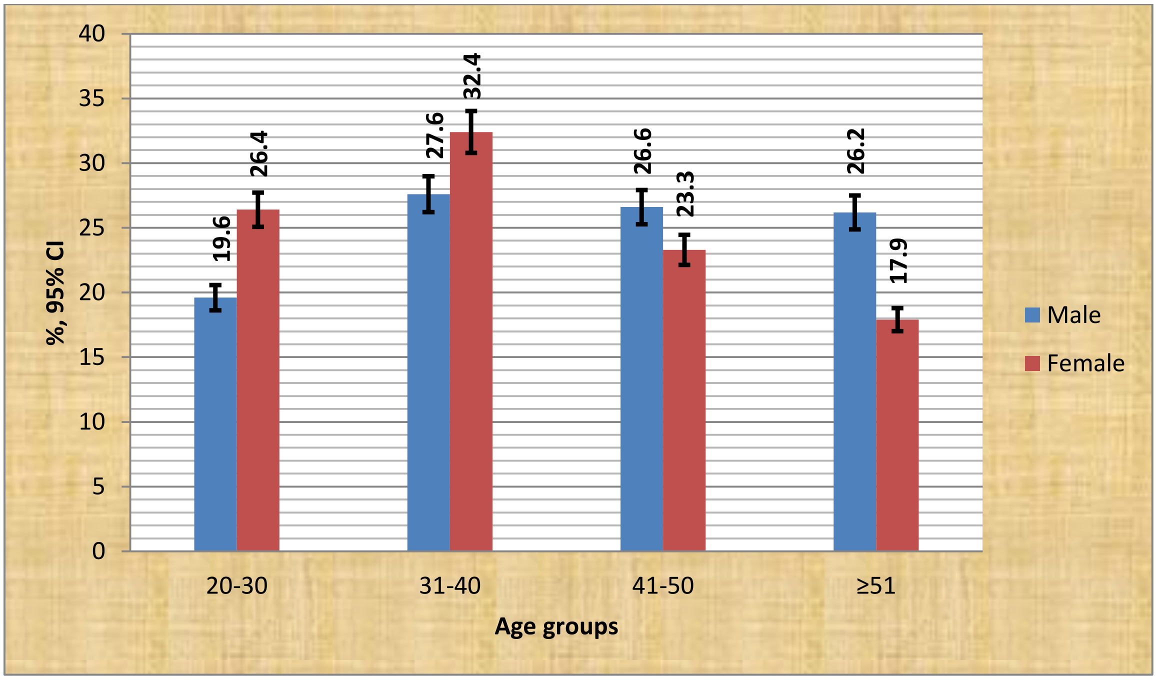

Figure 4.1: Bar diagram showing age and gender wise distribution of study participants with 95% CI

4.2 Clinical and biochemical characteristics of study population in both sexes (Table 4.2)

Clinical and biochemical characteristics of study population in both sexes adjusted for age are shown in Table 4.2. Men had considerably higher mean of SBP, FPG, and TG but lower level of HDL-C value than women. No significant difference in the mean of LDL, 2hPG and DBP between men and women was found in this population. Prevalence of HTN, DM and dyslipidemia were 15.5 % (14.1, 17.0), 7.9% (6.8, 9.0) and 28.7% (26.9, 30.5) respectively. HTN and dyslipidemia were significantly higher in men but no significant sex difference observed for DM.

Table 4.2: Clinical and biochemical characteristics of study population in both sexes

Variables	Total (2293)	Male (842)	Female (1451)	P-value Male Vs Female
SBP (mmHg)	116.2 (115.6, 116.9)	117.2 (116.2, 118.3)	115.2 (114.4, 116.1)	0.002
DBP (mmHg)	77.1 (76.6, 77.5)	77.6 (76.9, 78.2)	76.5 (76.0, 77.1)	0.499
Hypertension (%)	15.5 (14.1, 17.0)	17.5 (15.1, 20.0)	14.3 (12.5, 16.1)	0.034
FPG (mmol/L)	5.2 (5.1, 5.3)	5.3 (5.2, 5.5)	5.1 (5.0, 5.2)	0.002
2hPG (mmo/L)	6.3 (6.2, 6.4)	6.3 (6.1, 6.5)	6.2 (6.1, 6.4)	0.499
Diabetes (%)	7.9 (6.8, 9.0)	9.1 (7.2, 11.0)	7.2 (5.8, 8.5)	0.101
Chol (mmol/L)	4.32 (4.29, 4.36)	4.33 (4.28, 4.38)	4.32 (4.28, 4.36)	0.800
TG* (mmol/L)	1.38 (1.35, 1.40)	1.43 (1.39, 1.48)	1.32 (1.29, 1.36)	<0.001
HDL (mmol/L)	0.90 (0.89, 0.91)	0.86 (0.84, 0.97)	0.93 (0.92, 0.94)	<0.001
LDL (mmol/L)	2.75 (2.72, 2.78)	2.74 (2.69, 2.78)	2.76 (2.72, 2.79)	0.515
Dyslipidemia (%)	28.7 (26.9, 30.5)	35.3 (32.1, 38.5)	24.8 (22.6, 27.0)	<0.001

Data are mean (95% confidence interval) or percentage (95% confidence interval) adjusted for age as indicated. *Geometric mean (95% confidence interval) for triglyceride (TG). Dyslipidemia: fasting TG ≥1.7 mmol/L and high-density lipoproteins (HDL) <1.04 mmol/L (male), <1.29 mmol/L (female). Diabetes: diagnosed according to World Health Organization 1999 criteria20. Hypertension: systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg21. 2hPG, 2-h plasma glucose; BMI, body mass index; DM, diabetes mellitus; FPG, fasting plasma glucose; WC, waist circumference; WHR, waist-to-hip ratio.; T-Chol; total cholesterol; LDL-C; low density lipoprotein cholesterol.

4.3 Age specific and age standardized prevalence of different Body Mass Index (BMI) levels (Table 4.3 and Figure 4.2)

Age specific and age standardized prevalence of different BMI levels are shown in Table 4.3. The age standardized prevalence of underweight, normal weight, overweight and obese were 14.3%, 41.9%, 17.7%, and 26.2%, respectively. No significant sex difference observed for prevalence of different BMI groups. With increasing age in female, underweight group showed an increasing trend and the trend was statistically significance.

Table 4.3: Age specific and age standardized prevalence of different Body Mass Index (BMI) levels

Variables	Age specific (year) prevalence, %				Age Standardized prevalence, % (95% CI)
	20-30	31-40	41-50	≥51	20-80 years
Underweight (BMI <18.5 Kg/m2)					
Total (n=328)	11.7	10.3	16.2	21.0	14.3 (12.9, 15.7)
Male	14.6	9.1	14.3	18.6	13.6 (11.3, 16.0)
Female	10.4	10.9	17.5	23.1[a]	14.9 (12.1, 16.8)
Normal weight (BMI 18.5-<23 Kg/m2)					
Total (n=960)	46.2	39.2	41.1	41.8	41.9 (39.9, 43.9)
Male	44.2	41.4	41.1	42.9	42.3 (38.9, 45.7)
Female	47.0	38.9	41.1	40.8	41.5 (38.9, 44.1)
Overweight (BMI 23-<25 Kg/m2)					
Total (n=405)	18.6	17.1	17.6	17.5	17.7 (16.1, 19.2)
Male	18.8	19.8	17.9	19.9	19.1 (16.5, 21.8)
Female	18.5	15.7	17.5	15.4	16.8 (14.9, 18.7)
Obese (BMI ≥25 Kg/m2)					
Total (n=600)	23.7	33.5	25.1	19.8	26.2 (24.4, 27.9)
Male	22.4	29.7	26.8	18.6	25.1 (22.1, 28.0)
Female	24.0	35.3	23.9	20.8	26.8 (24.5, 29.0)

Values are presented as % (number) or (95% confidence interval) as indicated. Age adjustment was based on 2001 census of Bangladesh.

[a]χ^2 trend=P<0.05 for different age group. CI, confidence interval; BMI, body mass index

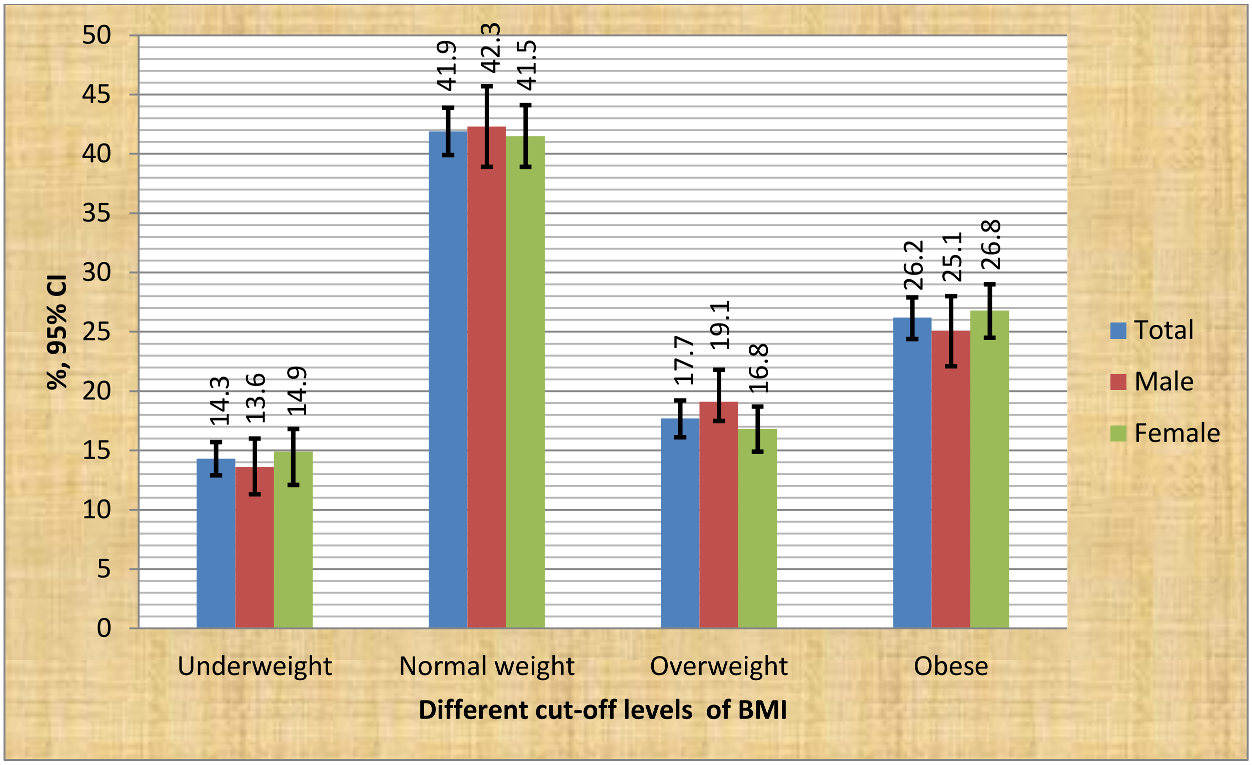

Figure 4.2: Age standardized prevalence of different BMI levels with 95% CI

4.4 Age specific and Age adjusted mean of Body Mass Index (BMI) by different levels (Table 4.4)

Age specific and age adjusted mean of body mass index (BMI) by different levels are shown in Table 4.4. The age adjusted mean of underweight, normal weight, overweight, obese and overall were 17.1, 20.8, 23.9, 27.7 and 22.4 kg/m^2 respectively. Statistically difference between the two sexes was noticed in the age adjusted mean of obese group (27.3 kg/m^2 in male and 27.9 kg/m^2 in female; P<0.05). There was no mean difference found between the age groups in all the categories.

Table 4.4: Age specific and Age adjusted mean of Body Mass Index (BMI) by different levels

	Age specific (year) means (95% CI)				Age adjusted mean (95% CI)
	20-30	31-40	41-50	≥51	
Underweight (N =328)					
Total	17.1 (16.8, 17.3)	17.5 (17.3, 17.7)	17.1 (16.9, 17.4)	16.7 (16.5, 16.9)	17.1 (16.9, 17.2)
Male	17.0 (16.5, 17.5)	17.6 (17.2, 18.1)	17.2 (16.7, 17.7)	16.8 (16.4, 17.2)	17.1 (16.9, 17.3)
Female	17.1 (16.8, 17.4)	17.5 (17.2, 17.7)	17.1 (16.8, 17.4)	16.7 (16.4, 17.2)	17.1 (16.9, 17.2)
Normal weight (N=960)					
Total	20.8 (20.6, 20.9)	20.8 (20.6, 20.9)	20.9 (20.7, 21.0)	20.8 (20.6, 23.0)	20.8 (20.7, 20.9)
Male	20.7 (20.4, 21.0)	20.8 (20.6, 21.1)	20.8 (20.5, 21.1)	20.8 (20.5, 21.0)	20.8 (20.7, 20.9)
Female	20.8 (20.6, 21.0)	20.8 (20.6, 20.9)	20.9 (20.7, 21.1)	20.8 (20.6, 21.1)	20.8 (20.7, 20.9)
Overweight (N=405)					
Total	23.9 (23.8, 24.1)	23.9 (23.8, 24.1)	23.9 (23.8, 24.0)	23.9 (23.8, 24.0)	23.9 (23.8, 24.0)
Male	23.9 (23.7, 24.1)	23.9 (23.8, 24.2)	23.9 (23.8, 24.0)	23.9 (23.7, 24.0)	23.9 (23.8, 24.0)
Female	24.0 (23.8, 24.1)	24.0 (23.8, 24.1)	23.9 (23.8, 24.1)	23.9 (23.8, 24.0)	23.9 (23.8, 24.0)
Obese (N=600)					
Total	27.6 (27.2, 28.0)	27.9 (27.6, 28.2)	27.6 (27.2, 28.0)	27.3 (26.8, 27.7)	27.7 (27.5, 27.9)
Male	27.3 (26.6, 27.9)	27.3 (26.9, 27.7)	27.4 (26.7, 28.1)	27.1 (26.3, 27.8)	27.3 (27.0, 27.6)
Female	27.3 (27.0, 28.3)	28.2 (27.8, 28.6)	27.7 (27.2, 28.2)	27.4 (26.9, 28.0)	27.9 (27.7, 28.1)[b]
Overall (N=2293)					
Total	22.6 (22.2, 22.9)	23.4 (23.1, 23.7)	22.5 (22.2, 22.8)	21.8 (21.4, 22.1)	22.4 (22.3, 22.5)
Male	22.3 (21.7, 22.8)	23.1 (22.6, 23.5)	22.6 (22.1, 23.1)	21.8 (21.3, 22.3)	22.3 (22.2, 22.4)
Female	22.7 (22.3, 23.1)	23.5 (23.2, 23.9)	22.4 (21.9, 22.8)	21.7 (21.2, 22.2)	22.4 (22.3, 22.5)

Values are presented as mean (95% confidence interval) as indicated.

[b]P<0.05 between male and female in same group CI, confidence interval; BMI, body mass index

4.5 Age specific and age standardized prevalence of central obesity based on Waist circumference (WC) and Waist hip ratio (WHR) (Table 4.5 and Figure 4.3)

Age specific and age standardized prevalence of central obesity based on Waist circumference (WC) and Waist hip ratio (WHR) are shown in Table 4.5. The age standardized prevalence of central obesity based on WC and WHR were 39.8% and 71.6% respectively. In age standardized prevalence of central obesity, both WC and WHR showed significant sex differences. The prevalence of central obesity by WHR demonstrated that a growing trend with increasing age in female and the trend was statistically significance.

Table 4.5: Age specific and age standardized prevalence of central obesity based on Waist circumference (WC) and Waist hip ratio (WHR)

Variables	Age specific (year) prevalence, %				Age Standardized prevalence, % (95% CI)
	20-30	31-40	41-50	≥51	20-80 years
Central Obesity by WC (cm)					
Total (M ≥90 & F ≥80)	34.9	46.3	41.6	33.9	39.8 (37.9, 41.7)
Male (≥90 cm)	16.4	28.9	29.9	19.9	24.3 (21.4, 27.1)
Female (≥80 cm)	42.8	54.9	49.4	45.8	48.7 (46.2, 51.3)[b]
Central Obesity by WHR					
Total (M ≥0.90 & F ≥0.80)	66.6	73.1	73.8	72.6	71.6 (69.8, 73.4)
Male (≥0.90)	43.6	64.7	63.4	60.6	58.4 (55.2, 61.8)
Female (≥0.80)	76.5	77.2	80.8	82.7[a]	79.1 (76.9, 81.1)[b]

Values are presented as % (number) or (95% confidence interval) as indicated. Age adjustment was based on 2001 census of Bangladesh.

CI, confidence interval

[a]χ^2 trend=$P<0.05$ Central Obesity based on WC and WHR, [b]$P<0.05$ between male and female in same group

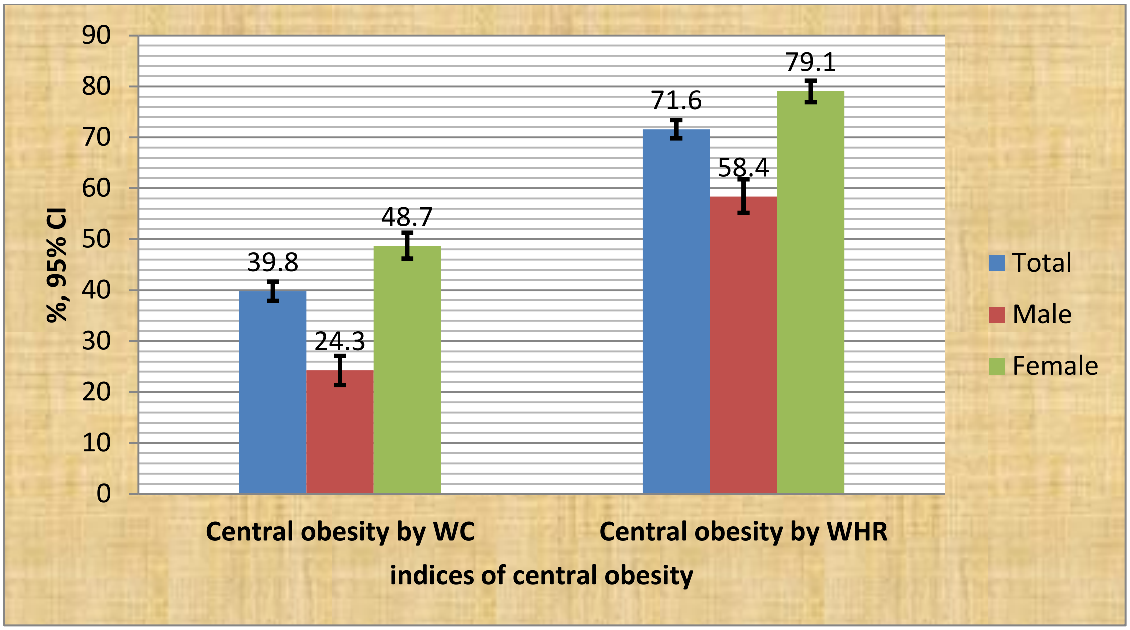

Figure 4.3: Age standardized prevalence of central obesity with 95% CI define by WC and WHR

4.6 Age specific and age adjusted mean of waist circumference (WC) and waist hip ratio (WHR), by sex (Table 4.6)

Age specific and age adjusted mean of waist circumference (WC) and waist hip ratio (WHR), by sex shown in Table 4.6. The age adjusted mean of central obesity based on WC and WHR were 80.5 cm and 0.88 respectively. Statistically difference between the two sexes was noticed in the age adjusted mean of central obesity by WC (81.8 cm in male and 79.7 cm in female; $P<0.05$) and WHR (0.91 in male and 0.86 in female; P<0.05). There was statistically significant mean difference found between the age groups in total and female sex.

Table 4.6: Age specific and age adjusted mean of Waist circumference (WC) and Waist hip ratio (WHR), by sex

Variables	Age specific (year) means, 95% CI				Age adjusted
	20-30	31-40	41-50	≥51	Mean (95% CI)
Central Obesity by WC (cm)					
Both sex (M ≥90 & F ≥80)	79.2 (78.4, 80.1)	81.8 (81.6, 82.6)	81.0 (80.1, 81.8)	79.5 (78.4, 80.4)[a]	80.5 (80.1, 80.9)
Male (≥90 cm)	80.0 (78.4, 81.5)	83.1 (81.9, 84.3)	82.8 (81.4, 84.1)	80.8 (79.4, 82.2)	81.8 (81.1, 82.5)
Female (≥80 cm)	78.9 (77.9, 79.9)	81.2 (80.2, 82.2)	79.8 (78.7, 80.9)	78.2 (76.8, 79.7)[a]	79.7 (79.2, 80.3)[b]
Central Obesity by WHR					
Both sex (M ≥0.90 & F ≥0.80)	0.86 (0.85, 0.87)	0.88 (0.86, 0.89)	0.89 (0.88, 0.90)	0.89 (0.88, 0.90)[a]	0.88 (0.87, 0.89)
Male (≥0.90)	0.89 (0.87, 0.90)	0.91 (0.90, 0.92)	0.92 (0.91, 0.93)	0.91 (0.90, 0.92)	0.91 (0.90, 0.93)
Female (≥0.80)	0.85 (0.84, 0.86)	0.86 (0.85, 0.87)	0.87 (0.86, 0.88)	0.87 (0.86, 0.88)[a]	0.86 (0.85, 0.87)[b]

Values are presented as mean (95% confidence interval). Age adjustment was based on 2001 census of Bangladesh.

CI, confidence interval. [a]P<0.05 between age group: [b]P<0.05 between male and female in same group

4.7 The prevalence of central obesity based on WC and WHR by BMI levels (Table 4.7 and Figure 4.4)

The prevalence of central obesity based on WC and WHR significantly differed among categories of BMI. The prevalence of central obesity by WC and WHR were 2.4% and 36.0% for subjects with underweight (BMI <18.5 kg/m^2), 16.4% and 64.1% for those with normal-weight (BMI 18.5-22.9 kg/m^2), 54.3% and 87.2% for subjects with overweight (BMI 23-24.9 kg/m^2) and 88.0% and 92.7% for obese subjects (BMI ≥25 kg/m^2) respectively.

Table 4.7: The prevalence of central obesity based on WC and WHR by BMI levels

		Central obesity			
		WC (cm)		WHR	
BMI (Kg/m^2)	Total	Number	Prevalence (%, 95% CI)	Number	Prevalence (%, 95% CI)
Underweight (BMI <18.5)	328	8	2.4 (1.2, 4.8)	118	36.0 (31.0, 41.3)
Normal-weight (BMI 18.5-22.9)	960	157	16.4 (14.2, 18.8)	615	64.1 (60.1, 67.0)
Overweight (BMI 23-24.9)	405	220	54.3 (49.5, 59.1)	353	87.2 (83.6, 89.2)
Obese (BMI ≥25)	600	528	88.0 (85.2, 90.4)	556	92.7 (90.3, 94.5)
Total	2293	913	39.8	1144	78.8
p value			<0.001		<0.001

BMI, body mass index; WC, waist circumference; WHR, waist hip ratio

P for comparison among different BMI categories

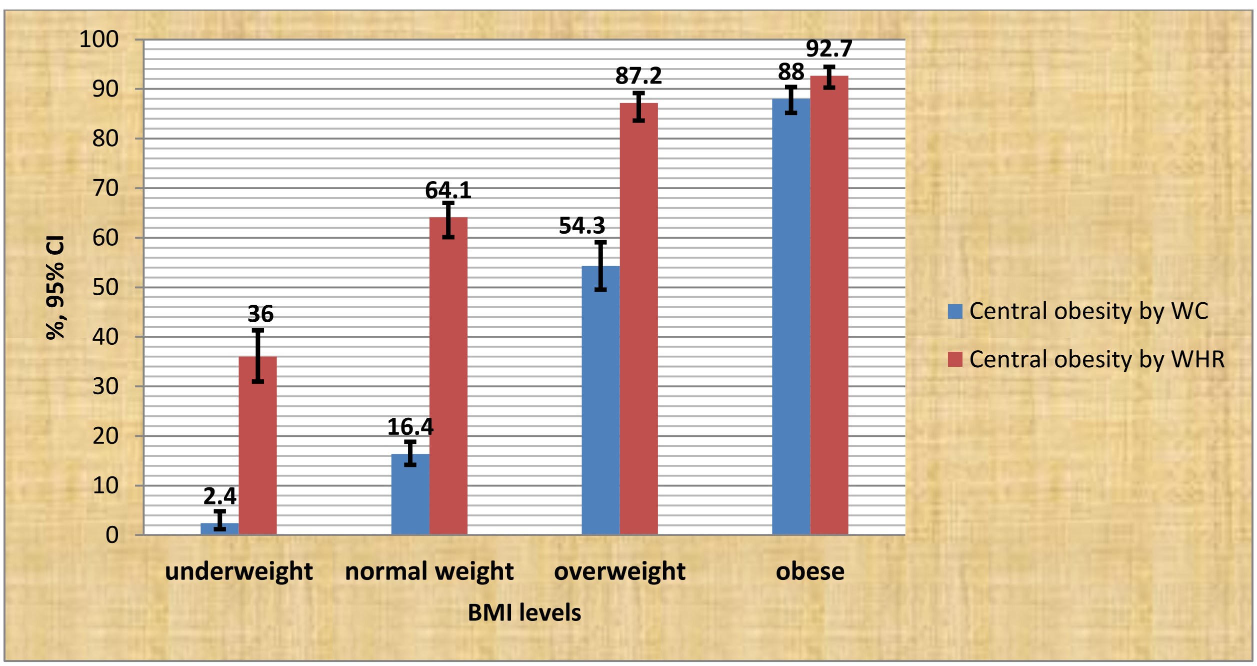

Figure 4.4: The prevalence of central obesity with 95% CI based on WC and WHR by BMI levels

4.8 Prevalence of generalized obesity based on different BMI (kg/m^2) cut-off level and their adjusted odds for predicting diabetes mellitus (Table 4.8 and Figure 4.5)

Table 4.8 shows the age adjusted prevalence of generalized obesity based on different BMI cut-off levels and their adjusted odds for estimating diabetes mellitus. The overall age adjusted prevalence of obesity using the WHO definition of BMI ≥30kg/m^2 for western population was 3.8%, CI: 3.0, 4.5 (women: 4.6% > men: 2.3%). However, using the BMI ≥27.5 for Asian population, it was 10.9%. CI: 9.6, 12.2 (women: 11.8% > men: 9.2%), at the same time as using cut-off levels recommended by the International Association for the Study of Obesity BMI ≥25, it was 26.2%, CI: 24.4–27.9 (women: 26.8% > men: 25.1%), and lastly, using the new definition of BMI ≥23, it was 17.7% CI: 16.1, 19.2 (women: 16.8% < men: 19.1%). The adjusted ORs was highest for BMI ≥25 (OR: 2.12) for predicting DM compared to other three groups.

Table 4.8: Prevalence of generalized obesity based on different BMI (kg/m^2) cut-off level and their adjusted odds for predicting diabetes mellitus

BMI level	Total N (%)	Diabetes N (%)	Normal N (%)	OR (95% CI)[e]	P value for OR
≥23 kg/m^2 [a]	405 (17.7)	39 (9.6)	366 (90.4)	1.26 (0.87, 1.83)	0.228
≥25 kg/m^2 [b]	601 (26.2)	72 (12.0)	529 (88.0)	2.12 (1.53, 2.93)	<0.001
≥27.5 kg/m^2 [c]	250 (10.9)	31 (12.4)	219 (87.6)	1.93 (1.27, 2.94)	0.002
≥30 kg/m^2 [d]	86 (3.8)	10 (11.6)	76 (88.4)	1.78 (0.89, 3.53)	0.098

BMI, body mass index; OR, odd ratio; CI, confidence interval

A, b: overweight and obesity cut-off levels recommended by the International Association for the Study of Obesity and the International Obesity Task Force for Asian population (33)

c: obesity cut-off level recommended by WHO for Asian population (33)

d: obesity cut-off level recommended by WHO for western population (32)

e: adjusted with age, sex, smoking and physical activity

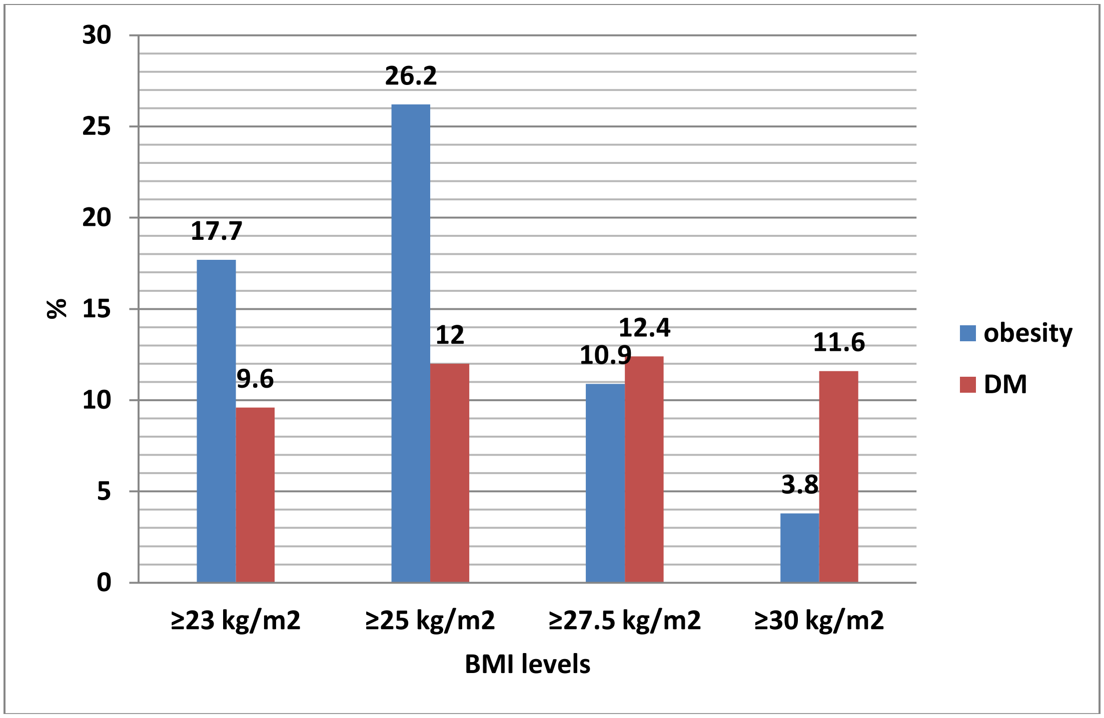

Figure 4.5: Prevalence of obesity and T2DM based on different BMI levels

4.9 Prevalence of Obesity based on different socio-demographic condition of study population (Table 4.9 and Figure 4.6)

Table 4.9 shows prevalence of obesity based on different socio-demographic condition of study population. In education level, obesity rate was lower in college and above level than illiterate, primary and secondary level. Obesity rate was higher in participants belonging in high socioeconomic status and participants who were nonsmoker and physically inactive.

Table 4.9: Prevalence of Obesity based on different socio-demographic condition of study population

Variables	Obesity prevalence n, (%)	P value
Education level		<0.001
Illiterate	299 (28.8)	
Primary	120 (28.6)	
Secondary	156 (24.9)	
College & above	26 (12.4)	
Socioeconomic status		<0.001
Low	173 (18.2)	
Medium	262 (27.1)	
High	166 (44.5)	
Smoking habits		<0.001
No	541 (28.1)	
Yes	60 (16.4)	
Physical activity level		<0.001
Active	489 (25.1)	
Inactive	112 (32.3)	

P value: within group variables

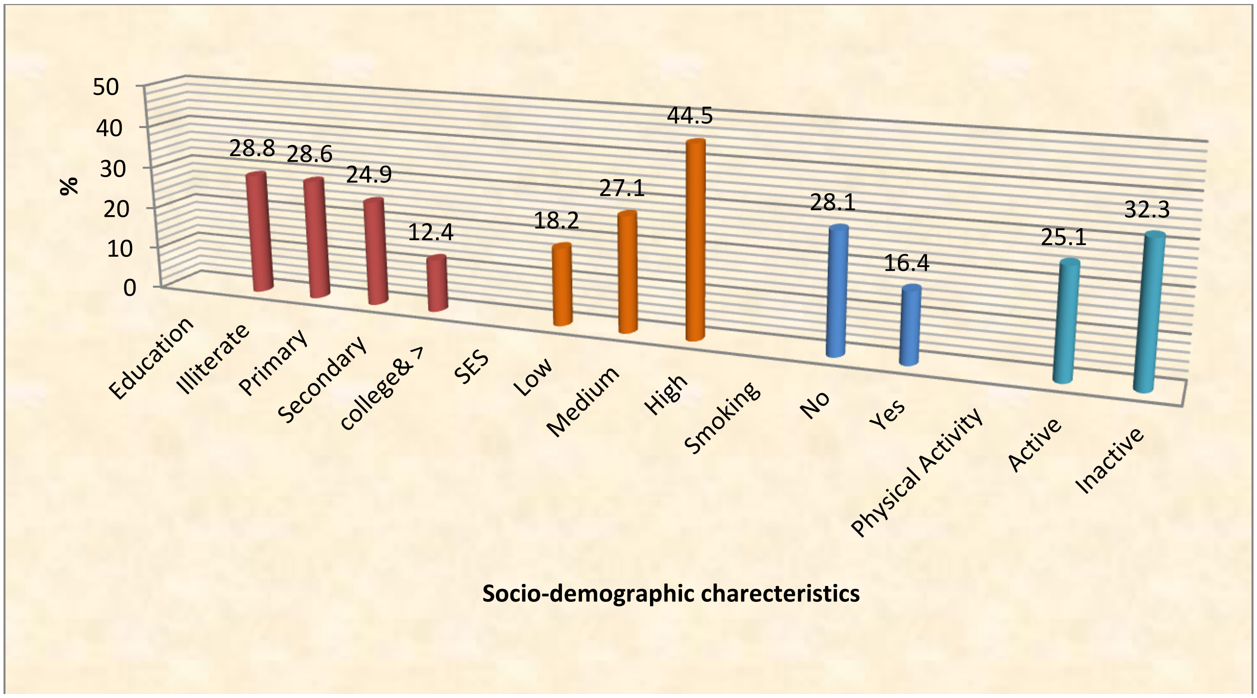

Figure 4.6: Prevalence of obesity based on different socio-demographic condition of study population

4.10 Association between general (BMI ≥25 Kg/m2) and central obesity (WC: M ≥90 & F ≥80) and socio-demographic factors in the surveyed population aged ≥20 years (Table 4.10)

Table 4.10 shows middle age, medium and high SES, illiterate, primary and secondary education, physical inactivity, high consumption of carbohydrate, protein and fat, were some significant risk indicators for generalized and central obesity. Additionally, females had significant risk factor for central obesity. Smoking was protective factor for both generalized and central obesity.

Table 4.10: Association between general (BMI ≥25 Kg/m^2) and central obesity (WC: M ≥90 & F ≥80) and socio-demographic factors in the surveyed population aged ≥20 years

	Generalized obesity (BMI)			Central obesity (WC)		
Valuable	OR	95% CI	P value	OR	95% CI	P value
Age (years)						
20-30	Ref			Ref		
31-40	1.63	1.25, 2.13	<0.001	1.69	1.32, 2.16	<0.001
41-50	1.22	0.84, 1.49	0.431	1.56	1.20, 2.03	0.001
≥51	0.75	0.54, 1.03	0.075	1.05	0.79, 1.38	0.741
Sex						
Male	Ref			Ref		
Female	1.05	0.81, 1.35	0.739	3.70	2.86, 4.79	<0.001
Education						
Higher	Ref			Ref		
Secondary	2.34	1.49, 3.67	<0.001	2.13	1.47, 3.91	<0.001
Primary	2.84	1.79, 4.51	<0.001	2.65	1.79, 3.91	<0.001
Illiterate	2.87	1.86, 4.42	<0.001	3.32	2.33, 4.74	<0.001
SES						
Low	Ref			Ref		
Medium	1.69	1.35, 2.12	<0.001	1.59	1.30, 1.94	<0.001
High	3.42	2.60, 4.50	<0.001	2.91	2.24, 3.81	<0.001
Smoking						
No	Ref			Ref		
Yes	0.48	0.34, 0.68	<0.001	0.70	0.51, 0.97	0.031
Physical activity						
active	Ref			Ref		
inactive	1.58	1.17, 2.14	0.003	1.78	1.32, 2.39	<0.001
Carbohydrate intake (%)						
≤55%	Ref			Ref		
>55%	2.78	2.00, 4.00	<0.001	2.87	2.04, 4.05	<0.001
Protein intake (%)						
<15%	Ref			Ref		
≥15%	1.25	1.01, 1.55	0.039	1.26	1.02, 1.56	0.036
Fat intake (%)						

<30%	Ref			Ref		
≥30%	1.78	1.19, 2.65	0.005	1.78	1.19, 2.67	0.005

Adjusted by age, sec, educational status, socioeconomic status (SES), smoking, physical activity, depression, carbohydrate, protein and fat intake.

BMI, body mass index; WC, waist circumference

4.11 The prevalence of IFG, IGT and DM by General obesity based on BMI (Table 4.11 and Figure 4.7)

Table 4.11 shows the prevalence of IFG, IGT and DM by general obesity based on different BMI levels. The rates of IFG for subjects with underweight (BMI <18.5 kg/m^2), normal-weight (BMI 18.5-22.9 kg/m^2), overweight (BMI 23-24.9 kg/m^2) and obesity (BMI ≥ 25 kg/m^2) were 3.7%, 2.2%, 4.4% and 4.7% respectively and the prevalence rates of IGT for those four BMI categories were 2.4%,4.2%, 3.7% and 9.2% respectively. The rates of DM were 2.7%, 6.4%, 9.6% and 12% respectively for those four BMI categories.

Table 4.11: The prevalence of IFG, IGT and DM by General obesity based on BMI

		IFG		IGT		DM	
	Total	No	Prevalence (%, 95 CI)	No	Prevalence (%, 95% CI)	No	Prevalence (%, 95% CI)
<u>**BMI (Kg/m^2)***</u>							
Underweight (BMI <18.5)	328	12	3.7 (2.1, 6.2)	8	2.4 (1.2, 4.7)	9	2.7 (1.5, 5.1)
Normal-weight (BMI 18.5-22.9)	960	21	2.2 (1.4, 3.3)	40	4.2 (3.1, 5.6)	61	6.4 (5.0, 8.1)
Overweight (BMI 23-24.9)	405	18	4.4 (2.8, 6.9)	15	3.7 (2.3, 6.0)	39	9.6 (7.1, 12.9)
Obese (BMI ≥25)	600	28	4.7 (3.3, 6.7)	55	9.2 (7.1, 11.7)	72	12 (9.6, 14.8)
Total	2293	79	3.4 (2.8, 4.8)	118	5.1 (4.3, 6.1)	181	7.9 (6.9, 9.1)
p value			.036		<0.001		<0.001

IFG, impaired glucose tolerance; IGT, impaired glucose tolerance; DM, diabetes mellitus; BMI, body mass index; CI, confidence interval

*Based on the diagnostic criteria for Asian population (33)

P for comparison among different BMI categories

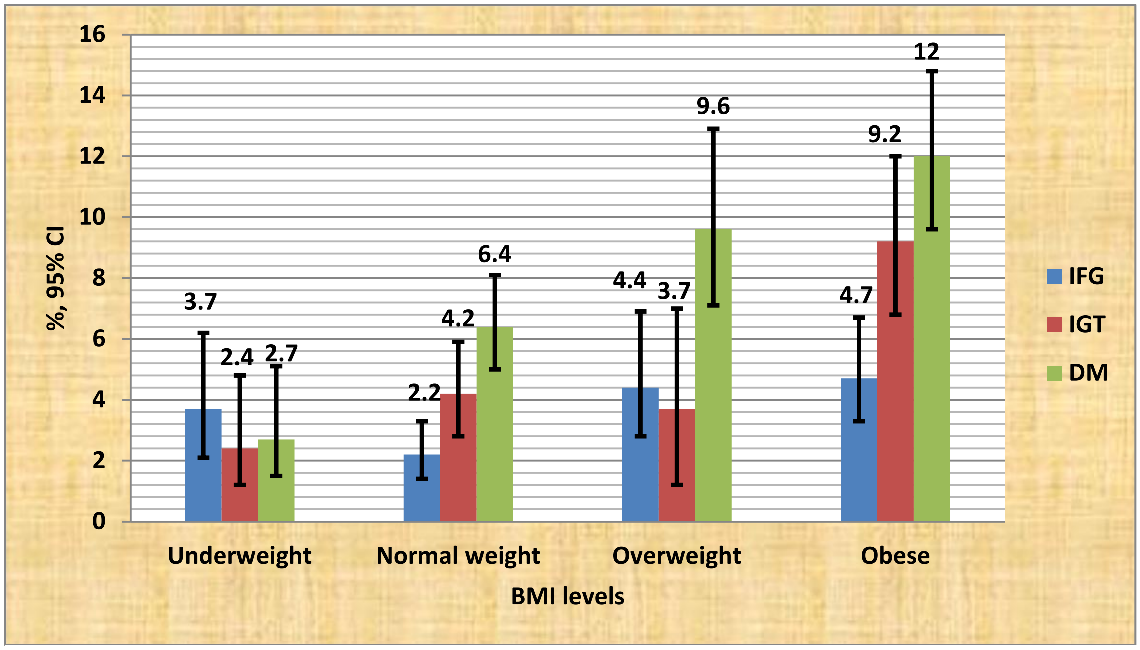

Figure 4.7: The prevalence of IFG, IGT and DM by General obesity (with 95% CI) based on BMI

4.12: The prevalence of IFG, IGT and DM by Central obesity based on WC and WHR (Table 4.12 and Figure 4.8)

Table 4.12 shows the prevalence of IFG, IGT and DM by central obesity based on WC and WHR. The IFG prevalence rates for subjects with WC within the normal range and those considered obese were 3.0% and 4.1% respectively, whereas the IGT prevalence rates for the two groups were 3.5% and 7.7% respectively. The prevalence rates of DM were 5.3% and 11.8% respectively for the WC categories.

The rates of IFG for subjects with WHR within the standard range and those measured obesity were 2.8% and 3.7% respectively and the prevalence rates of IGT for those two WHR categories were 3.2% and 5.9% respectively, while the prevalence rates of DM were 2.9% and 9.9% respectively for those two WHR categories.

Table 4.12: The prevalence of IFG, IGT and DM by Central obesity based on WC and WHR

		IFG		IGT		DM	
	Total	No	Prevalence (%)	No	Prevalence (%)	No	Prevalence (%)
WC (cm)*							
Normal (M <90 & F <80)	1380	42	3.0 (2.3, 4.1)	48	3.5 (2.6, 4.6)	73	5.3 (4.2, 6.6)
Obese (M ≥90 & F ≥80)	913	37	4.1 (3.0, 5.5)	70	7.7 (6.1, 9.6)	108	11.8 (9.9, 14.1)
Total	2293	79	3.4 (2.8, 4.3)	118	5.1 (4.3, 6.1)	181	7.9 (6.9, 9.1)
P value			0.195		<0.001		<0.001
WHR*							
Normal (M <.90 & F <.80)	651	18	2.8 (1.8, 4.3)	21	3.2 (2.1, 4.9)	19	2.9 (1.9, 4.5)
Obese (M ≥.90 & F ≥.80)	1642	61	3.7 (2.9, 4.7)	97	5.9 (4.9, 7.2)	162	9.9 (8.5, 11.4)
Total	2293	79	3.4 (2.8, 4.3)	118	5.1 (4.3, 6.1)	181	7.9 (6.9, 9.1)
P value			0.318		<0.012		<0.001

IFG, impaired glucose tolerance; IGT, impaired glucose tolerance; DM, diabetes mellitus; WC, waist circumference; WHR, waist hip ratio; M, male; F, female

*Based on the diagnostic criteria for Asian population (33)

P for comparisons among different categories of WC and WHR, respectively

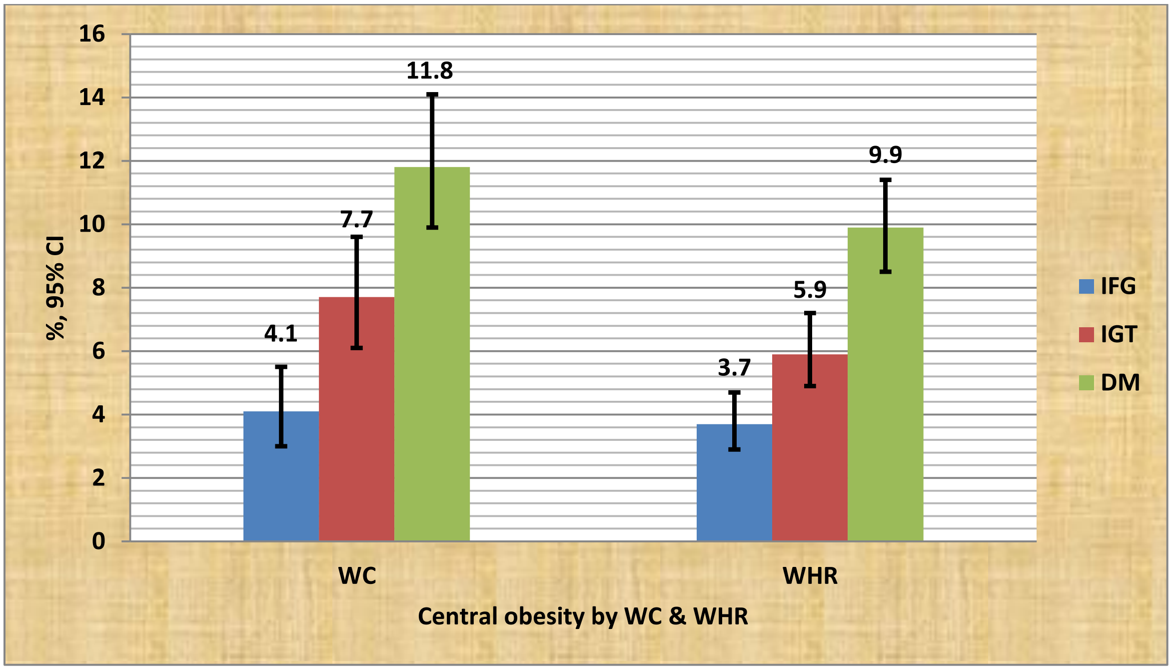

Figure 4.8: The prevalence of IFG, IGT and DM by Central obesity (with 95% CI) based on WC and WHR

4.13 Anthropometric characteristics by sex and diabetes status are demonstrated (Table 4.13 and Figure 4.9)

Anthropometric characteristics by sex and diabetes status are demonstrated in Table 4.13. Both males and females with DM had a significantly greater mean weight, BMI, WC and WHR. Additionally, in both sexes, study subjects with DM had higher rate of general obesity (defined by BMI) and central obesity (defined by WC and WHR) than non DM subjects.

Table 4.13: Anthropometric characteristics of study population by sex and diabetes status

	Men (842)			Women (1451)		
	No diabetes	Diabetes	P value	No diabetes	Diabetes	P value
Number	762	80 (9.5%)		1350	101 (7.0%)	
Weight (kg)	58.5 (57.8, 59.3)	62.3 (60.2, 64.4)	0.001	50.9 (50.4, 51.5)	55.7 (53.9, 57.4)	<0.001
Height (m)	1.616 (1.612, 1.621)	1.623 (1.611, 1.635)	0.310	1.501 (1.498, 1.504)	1.506 (1.496, 1.517)	0.294
BMI (kg/m^2)	22.4 (22.1, 22.6)	23.6 (22.9, 24.3)	0.001	22.6 (22.4, 22.8)	24.5 (23.8, 25.2)	<0.001
BMI (≥25kg/m^2), %	23.7 (20.7, 26.7)	34.2 (23.7, 44.7)	0.037	25.7 (23.3, 28.0)	46.4 (36.6, 56.1)	<0.001
WC (cm)	81.2 (80.5, 81.9)	86.5 (84.5, 88.4)	<0.001	79.2 (78.6, 79.8)	86.2 (84.3, 88.1)	<0.001
WC (M ≥90 cm; F ≥80 cm), %	22.6 (19.7, 25.6)	40.8 (30.0, 51.7)	<0.001	46.8 (44.1, 49.5)	75.3 (66.9, 83.7)	<0.001
WHR	0.91 (0.90, 0.92)	0.94 (0.93, 0.95)	<0.001	0.86 (0.85, 0.87)	0.92 (0.90, 0.93)	<0.001
WHR (M≥0.90; F≥0.80), %	56.8 (53.3, 60.3)	82.0 (73.5, 90.6)	<0.001	77.7 (75.4, 79.9)	94.9 (90.6, 99.3)	<0.001

Data are mean (95% confidence interval) or percentage (95% confidence interval) adjusted for age as indicated

BMI: body mass index; WC: waist circumference; WHR: waist to hip ratio

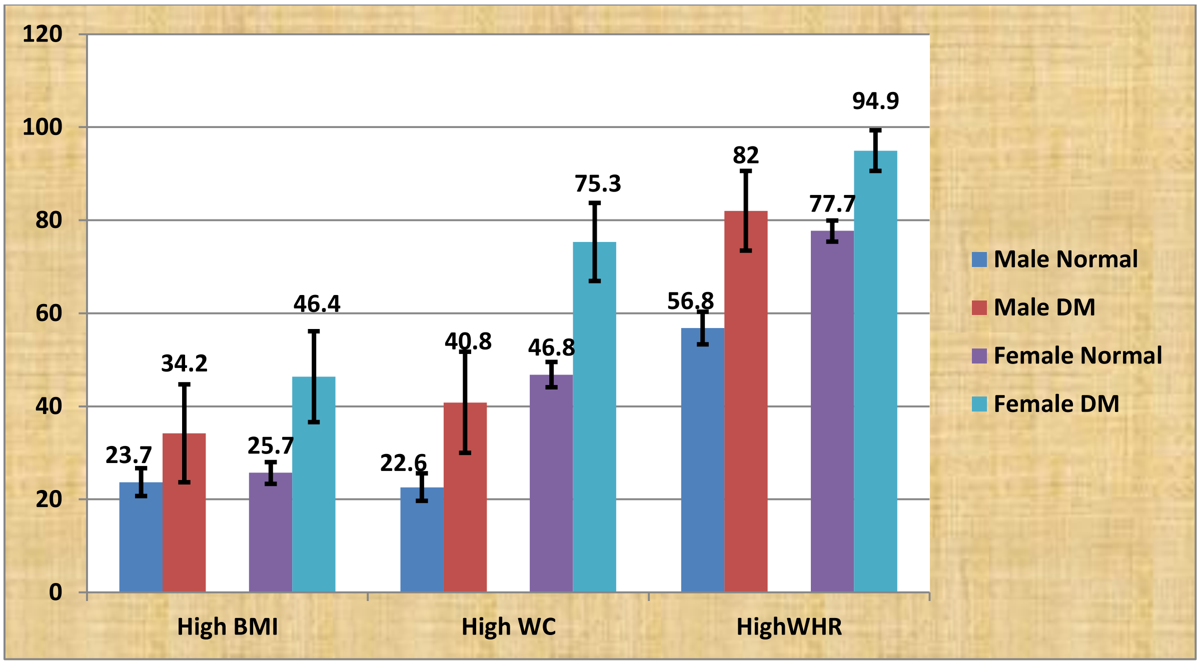

Figure 4.9: Prevalence of general and central obesity with 95% CI of study population by sex and diabetes status

4.14 Receiver operator curve characteristics for anthropometric variables in predicting diabetes (DM) and cut-off points for maximum sum of sensitivity and specificity in men and women (Table 4.14 and Figure 4.10)

Receiver operator curve (ROC) analysis was adapted to compare the diagnostic performance of the anthropometric indices to predict the presence of DM and to find out the optimal cut-off points for each index. These are presented in Table 4.14 and Fig. 4.10. ROC analysis showed the optimal cut-off points for DM detection were at a BMI of 21.2 kg/m^2 in men and 21.8 kg/m^2 in women, WC 82 cm in men and women and WHR 0.93 and 0.87 respectively. In spite of gender differences, WHR had the highest diagnostic values for the detection of DM in both sexes when compared with BMI and WC. Further, the AUC for both central obesity indices were notably higher than for BMI. The area under the ROC for WHR was larger than those of the other indices.

Table 4.14 Receiver operator curve characteristics for anthropometric variables in predicting diabetes (DM) and cut-off points for maximum sum of sensitivity and specificity in men and women

	Men				Women			
	AUC (95% CI)	Cut-off point	Sensitivity (%)	Specificity (%)	AUC (95% CI)	Cut-off point	Sensitivity (%)	Specificity (%)
BMI (kg/m^2)	0.62 (0.56, 0.68)	21.2	82.5	41.2	0.65 (0.60, 0.71)	21.8	77.2	46.5
WC (cm)	0.67 (0.61, 0.73)	82.0	76.2	53.7	0.70 (0.65, 0.75)	82.0	67.3	62.5
WHR	0.69 (0.63, 0.75)	0.93	68.8	60.9	0.73 (0.68, 0.78)	0.87	84.2	54.5

AUC: area under the receiver operating characteristic curve; BMI: Body mass index; WC: waist circumference; WHR: waist hip ratio. Comparison among anthropometric variables for predicting DM in men: BMI vs WC: χ^2 = 9.23, p=0.002; BMI vs WHR: χ^2 = 6.23, p=0.01; WC vs WHR. Comparison among anthropometric variables for predicting DM in women: BMI vs WC: χ^2 = 10.51, p=0.001; BMI vs WHR: χ^2 = 8.33, p=0.003; WC vs WHR: χ^2 = 3.52, p=0.06.

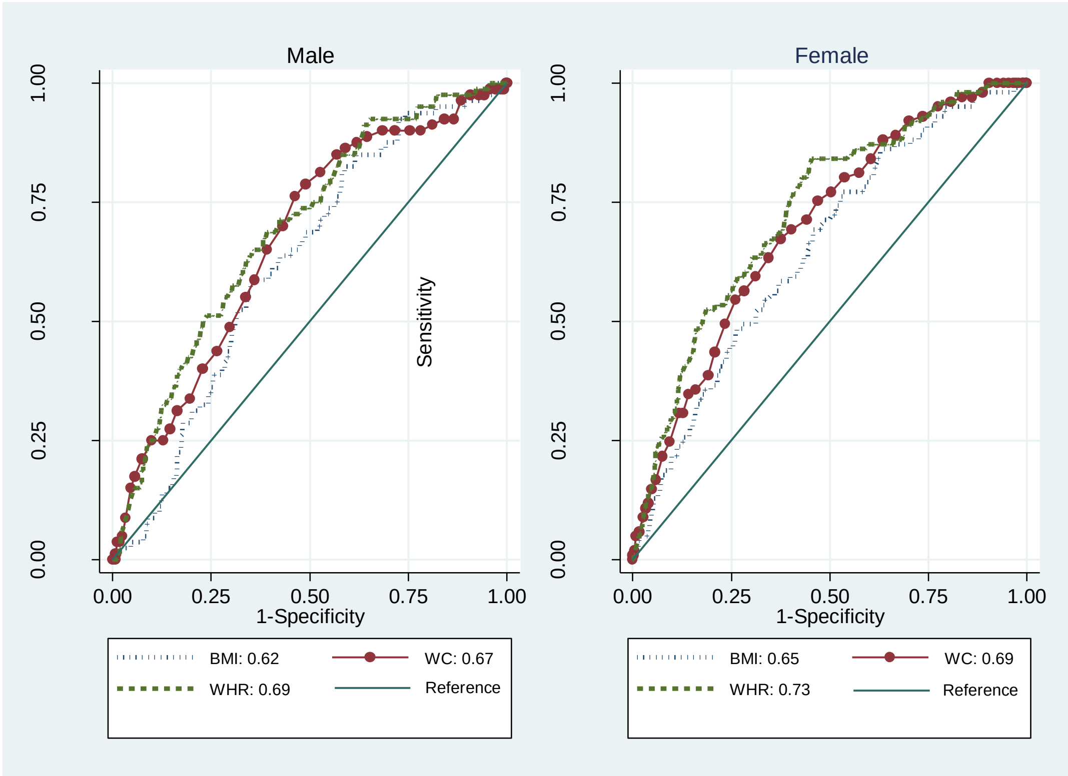

Figure 4.10: ROC (receiver operating characteristics) curve for body mass index (BMI), waist circumference (WC) and waist hip ratio (WHR) to predict diabetes mellitus (DM) by for men and women.

4.15 Unadjusted and adjusted odd ratios (ORs) of anthropometric indices for predicting DM (Table 4.15 and Figure 4.11)

Table 4.15 summarizes the independent relationships between the three anthropometric indices and the relative risk of having DM using both univariate and multiple logistic regression analysis after adjustment for age, social class, cigarette smoking and physical activity. The anthropometric indices, except for BMI, conferred a significant risk of DM in both unadjusted and adjusted models in men. WC and WHR were significantly associated with a 2- to 3-fold increase in risk for DM. Likewise all three obesity indices were significantly associated with DM, with a 2- to 5-fold increased risk in women. The unadjusted odds ratios for WHR and the presence of DM were higher than in the other indices, statistically significant $p < 0.001$, and greater in women 5.53 (2.23, 13.72) than men 3.60 (1.99, 6.52). After controlling for covariates using logistic regression analysis, the adjusted odds ratio in women 5.35 (2.15, 13.27), men 3.21 (1.76, 5.84) was only a little reduced and remained statistically significant $p < 0.001$ with positive associations greater in women.

Table 4.15 Unadjusted and adjusted odd ratios (ORs) of anthropometric indices for predicting DM

	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Men				
BMI (≥25 kg/m^2)	1.53 (0.93, 2.52)	0.091	1.50 (0.91, 2.51)	0.113
WC (≥90 cm)	2.27 (1.40, 3.66)	0.001	2.09 (1.28, 3.41)	0.003
WHR (≥0.90)	3.60 (1.99, 6.52)	<0.001	3.21 (1.76, 5.84)	<0.001
Women				
BMI (≥25 kg/m^2)	2.42 (1.60, 3.64)	<0.001	2.48 (1.63, 3.76)	<0.001
WC (≥80 cm)	3.45 (2.17, 5.49)	<0.001	3.47 (2.18, 5.53)	<0.001
WHR (≥0.80)	5.53 (2.23, 13.72)	<0.001	5.35 (2.15, 13.27)	<0.001

DM: diabetes mellitus; CI: confidence interval; BMI: body mass index; WC: waist circumference; WHR: waist hip ratio; after univariate logistic regression. Adjusted odds ratio after logistic regression analysis adjusted for age group (20-30, 31-40, 41-50 & ≥51), social class, cigarette smoking & physical activity.

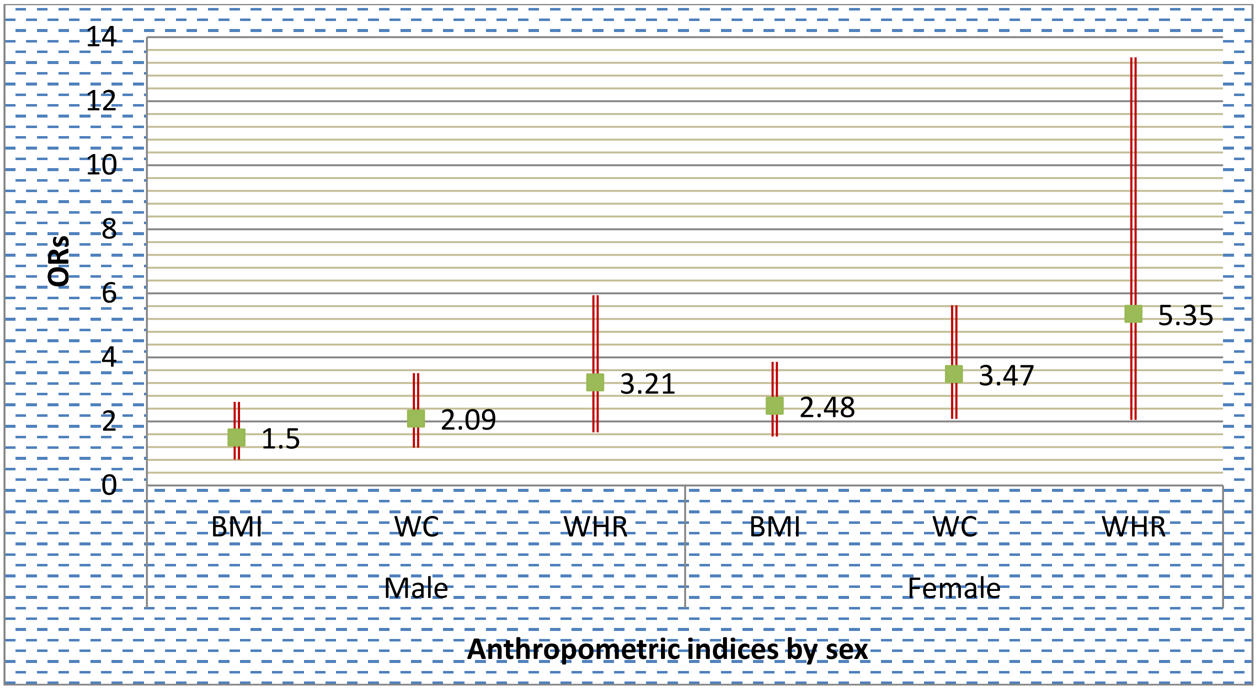

Figure 4.11: Adjusted odd ratios (ORs) of anthropometric indices for predicting DM by sex

Chapter 5: Discussion

5.1 Methodological Issues

5.1.1 Appropriateness of Study Design

Obesity is a growing public health concern in developing world. It is a common risk factor of major cardiometabolic diseases including T2DM, HTN, coronary artery disease etc. Primary objective of the study was to establish the prevalence of obesity in rural population of Bangladesh, where previous population based data do not exist following new Asian classification. Obesity, being frequent and long duration, was measured appropriately using cross-sectional study design. Another aims of study was to investigate the causative factors of obesity and its association with diabetes. To investigate the risk factors that may be associated with the occurrence and increment of obesity, cross-sectional studies are not the adequate methods to investigate causation. Since exposure and outcome are measured at the same time in a cross-sectional design, it is not possible to determine whether the described exposure preceded the disease or disease resulted from the exposure. However, the pathophysiological mechanism of causation of obesity and diabetes has been well workout, and findings from prospective studies were used to assist in the analysis and interpretation of results in cross sectional studies. Moreover, short duration of study period and limited budget are other reasons for selecting cross-sectional design.

5.1.2 Validity of Statistical Association

5.1.2.1 Samples size

The size of the sample of the population in a study is one of the main concerns in determining whether an observed association between exposure and outcome is due to chance alone. Small sample size than the required numbers may lead to β-error (we do not observe the association where there is an association). Furthermore, smaller sample size, is less likely to be representative of the population from where the sample is drawn. In 2009 study, around 3000 randomly selected individuals were invited to participate in the study. In order to determine required sample size for this study, the Student's formula was used.

n= Z^2PQ/d^2,

where, Z=1.96, P for prevalence (DM & impaired glucose regulation) rural area from the previous study i.e. 0.20; Q = 1-P i.e. 0.80 and d= allowable error of known prevalence i.e. 0.07 x 0.20. Ideally, it should be 0.05 x 0.20; but, to be on safe estimation with minimum sample size we allowed only 7% (or .06) error of prevalence.

Thus, n = $(1.96)^2$ (0.20)(0.80) / $[(0.07)(0.20)]^2$

Or, 0.614656/ 0.000196 = 3,136.

5.1.3 Bias

5.1.3.1 Selection bias

Selection bias refers to systematic errors in procedures that are used to select study populations or the factors that might influence participation in the study; therefore there is a systematic error in the identification of the study population. A low response rate could introduce selection bias, especially if the person responding or avoiding in participation in the study that have special characteristics which are associated with the exposure and outcomes measured.

In this study selection bias was not a major concern because the high response rate of both men and women.

5.1.3.2 Information bias

Information bias refers to methodical errors in the information obtained from the participants. These errors could be due to differences in the ways in which the interviewers or data collectors obtain information from the participants or to the participants themselves reporting information in a non- comparable way.

To avoid information biases related to the collection of socio-demographic data, well-trained interviewers from the local community were employed to conduct a reliable interview administering the questionnaire.

5.1.3.3 Measurement bias

Measurement bias occurs when the individual measurements or classification of disease or exposure are inaccurate, that is they do not measure correctly what they are supposed to measure. There are many sources of measurement bias and their effects are of varying importance. Biochemical and biophysical measurements are never completely accurate and different methods of investigation often produce different results on the same individual.

To avoid the measurement bias, all anthropometrical measurements including height, weight, waist and hip circumference were measured by the trained interviewers. For measuring weight, weight scales was standardized by measuring his/her own weight every day morning and were checked after every 20 patients and was calibrated. The anthropometries were recruited from the BIRDEM Hospital in Dhaka. He/she is trained and performs these measures as an everyday business.

Blood pressure was measured by the physician on the right arm using normal cuffs for adult fitted with a standard sphygmomanometer. The machine was checked every day before starting the measurement.

Quality control on the blood glucose measurement was checked by measuring the 2-hour plasma glucose values using the glucose oxidase methods in every 10th case.

5.1.4 Confounding

Confounding refers to a distortion of the estimated effect of an exposure on an outcome, caused by the presence of an extraneous factor associated both with the exposure and the outcome. In this study control of confounding was done by random selection of study subjects and effect of age in the prevalence of obesity and diabetes was minimized by stratification. The strength of individual risk from other confounders was controlled in multivariate analysis by logistic regression analysis.

5.1.5 Generalizability

The rural area was selected for this study. It should be noted that 72% of the Bangladesh population live in rural areas and the demographic of which is similar to the rest of the country. The entire populations (other than 2% tribal population) belong to the same ethnic group and speak the same language. Therefore it could be applicable to the whole of Bangladesh.

Nevertheless, we find comparable socio-demographic data for the rest of rural Bangladesh. Therefore, we believe that the data should be interpreted with caution but we have valid reasons to believe that the samples should have a fair representation for the rural Bangladesh. Moreover, the study was conducted in a reasonable large sample population.

5.2 Strengths of the study

1. It is a large scale population based study.

2. The samples were recruited randomly.

3. More than 72% of the population in Bangladesh is living in the rural areas. Therefore, the population is likely to be representative.

4. All the investigators, clinicians, anthropometrics and bio-technicians were recruited from the diabetic hospital of Bangladesh (BIRDEM), who was highly experienced.

5. All laboratory analysis was performed in the BIRDEM laboratory facilities, which has the highest credibility within the country.

6. The village leaders were included in the primary phase to avoid any selection bias and the local volunteers were recruited from the local communities to avoid any social or linguistic barrier.

7. Explore and compare the predictive abilities anthropometric indices including BMI, WC and WHR, for the presence T2DM. Study also explores optimal cut-off levels of these indices for predicting the T2DM.

5.3 Limitations of the study

1. This was a cross-sectional study, in epidemiological research cross-sectional study describes the exposure and outcomes at a time. In this study we estimated the prevalence of obesity and its risk indicators simultaneously. Therefore, we cannot say the identified risk factors are causally associated with obesity and its association with T2DM in our population.

2. This study was conducted in selected rural areas of Bangladesh. Therefore, the results may be interpreted with caution.

3. The anthropometric measurements were done once and thereby one cannot exclude the possibility for certain error since this was not controlled by a second observer.

4. The blood pressure was measured twice on an individual, but it could be ideal if we measured three times and took the average value.

5. AUCs of ROC analyses were not adjusted by age in the present study. Therefore, the relationship between each anthropometric measure and T2DM might be confounded by the influence of aging, underestimating the actual predictive value calculated in ROC analysis

5.4. Discussion on the main findings:

Obesity has become a major public health concern because of its adverse health consequences. Obesity most likely results from an interaction of genes and lifestyle factors. Although there are very few studies available from Asian Indians, no published information is available on the prevalence of obesity in rural Bangladeshi population. The present study was undertaken to explore prevalence of obesity, its associated risks and link with T2DM in rural Bangladeshi population aged ≥ 20 years.

Prevalence of Obesity:

Age specific and age standardized prevalence of overweight and obesity was 17.7% and 26.2% based on Asian specific cut-off levels of BMI. The prevalence of obesity documented in this study was comparatively higher than previous studies in Bangladesh conducted in different time points using different anthropometric cut-off levels **(26-28).** Prevalence rate in our study was found higher than rural areas of China (1.7%), Greece (10.0%) and north India (8%) **(132-134);** however, they used WHO cut-off levels for western population.

In our study, prevalence of overweight and obesity were 19.1 and 25.1% in men and 16.8 and 26.8% in women; however in Chinese rural population, prevalence of overweight and obesity were 15.1% and 1.2% in men, and 22.1% and 2.2% in women **(132)**. A study on a rural Pakistani population demonstrated that obesity levels among men and women were 19.5% and 24.7%, respectively **(135)**. In a recent study on rural population of Tamilnadu (South India) using Asian cut-offs for obesity was reported to be as high as 32.2% in males and 38.2% in females **(136).** Study have shown that in countries with relatively low gross national product, the prevalence is ~1.5–2 times higher among women than men whereas, in the developed countries, the prevalence of obesity is high in both men and women (**137**). In our study, the prevalence of obesity is slightly higher in women than men, while overweight is more prevalent in men. Our findings is also in accordance with the findings of a study conducted in Ghana where prevalence of obesity was found to be higher among women (7.4%) than men (2.8%) **(138)**. In Chinese rural study, a significantly high prevalence of overweight and obesity was observed in women than men. However, in Japan, men were more likely than women to be obese **(139)**. The observe difference between genders could be explained due to differences in lifestyle and socioeconomic status, as well as involvement of genetic or other behavioral factors.

In our study the prevalence of obesity in both men and women gradually decreased after 50 years but the prevalence of overweight had no obvious age differences. On the other hand, in Chinese rural study, considerable age-differences were also observed. As age increased, the prevalence of overweight decreased in men; however, the prevalence in women gradually decreased after 45 years of age. The prevalence of obesity had no obvious age differences **(132)**.

We have seen in South Asian study that the highest prevalence of obesity is observed in the middle aged (30-50 years) group, whereas in the UK prevalence tends to increase progressively with age (up to 64 years) **(140)**. In our study, the highest prevalence is reached in the middle-aged (30-40 years) group.

Our data show that the age standardized prevalence of central obesity based on WC (male ≥90 cm and women ≥80 cm) and WHR (male ≥0.90 cm and women ≥0.80 cm) was 39.8% and 71.6% for the study population. In the present analysis, more women had central obesity than men, as defined by the IDF for the Asian population **(45)**. This might be a consequence of the division of labor by sex in this community. Manual labor is sustained by male physical labor. The age-standardized prevalence of central obesity based on WC and WHR in the present study was 24.3%, 58.4% in men and 48.7%, 79.1% in women respectively. In southern part of India (Tamilnadu), prevalence rates of abdominal obesity, using Asian cut-offs, was present in 17.6% men and 23.7% women **(136)**.

In this study, the prevalence rate of central obesity based on WC and WHR by BMI levels was 39.8% and 78.8% for the total study population, 54.3% and 87.2% for those with high BMI (23-24.9 kg/m^2) and 88.0% and 92.7% for subjects considered obese with BMI ≥25 kg/m^2. In Chinese Study, the prevalence rate of central obesity based on WC was 33.97% for the total study population; 63.79% and 95.95% respectively for subjects with high BMI and those considered obese **(141).** In Indian urban study, it was 32.6 and 43.3% for men and women, respectively **(142).**

Prevalence of generalized obesity and their adjusted odds for predicting DM

The overall age adjusted prevalence rate of generalized obesity in this study was 3.8% using BMI ≥30; 10.9% using BMI ≥27.5; 26.2% using BMI ≥25; and 17.7% using BMI ≥23kg/m^2. We have found that the adjusted ORs were highest for BMI≥ 25 for predicting DM compared to other three groups. The age-standardized prevalence rate of generalized obesity in urban South Indians study was 4% using BMI ≥30; 9.9% using BMI ≥27.5; 26.5% using BMI ≥25; and 45.9% using BMI ≥23kg/m^2 **(142).** This is quite similar to figures reported from other Asian countries. The Chinese National Nutrition Survey showed that the prevalence of obesity (BMI ≥25) was 17.2% in Shanghai, 26.5% in Tianjin and 32.8% in Beijing **(143).** Using BMI ≥30, the prevalence of obesity among Hong Kong Chinese population was 2.2% in men and 4.8% in women, while using a cut point of BMI ≥27 in men and ≥25 in women, the prevalence was 10% in men and

27.9% in women **(144)**. In Malaysia, the prevalence of obesity using BMI (25–30) was 24% in men and 18.1% in women, while using BMI≥30; it was 4.7% in men and 7.7% in women **(145).** In Thailand, the prevalence of obesity was 16.7% using the cut point of BMI 25–30 and 4% using BMI ≥30 **(146)**. From the aforementioned information's we can understand that the prevalence of generalized obesity can be differ in the same population depending on the cut point used. It is therefore clear that defining obesity either by BMI or WC/WHR is purely arbitrary. Thus data from different ethnic groups using different obesity cut points should be interpreted with cautions.

Associated factors of obesity

Studies demonstrated that high prevalence of obesity was positively associated with female sex, middle age, higher educational and economic status, physical inactivity and some dietary habits in south Asian region **(147).** For instance, we have seen similar findings in our study except education level. Middle age, medium and high SES, physical inactivity, high intake of carbohydrate, protein and fat, were significant risk indicators for generalized and central obesity and in addition, females were significant risk indicators for central obesity. However, smoking was protective factor for both generalized and central obesity. Increased availability of energy-dense foods, excess carbohydrate based diet; physical inactivity may lead to weight gain and subsequently obesity in our population. Similarly, in China rural study showed that women were at greater risk of developing obesity as opposed to men. However, Chinese people with higher levels of education more likely became obese compared with those with low education. No group difference was observed with regard to the smoking status and age factor. Moderate physical activity was a protective factor when compared with low physical activity **(132).**

Prevalence of IFG, IGT and DM by general and central obesity

Based on our results it appears that the overall prevalence rate of IFG, IGT and DM by general obesity were 3.4%, 5.1% and 7.9% respectively. The rates of IFG, IGT and DM were found more among the obese (BMI ≥25 kg/m^2) group. The overall prevalence rates of IFG, IGT and DM by central obesity based on WC were 3.4%, 5.1% and 7.9% respectively. The IFG, IGT and DM prevalence rates were higher for subject's considered obese. The rates of IFG, IGT and DM were more among the subjects measured obese based on WHR. Similar findings were observed in InterASIA study. The overall prevalence rates for IFG and DM were 7.34% and 5.51%, respectively in Chinese population **(141).** The IFG prevalence rates for subjects with WC within the normal range and those considered obese were 5.96% and 10.04%, respectively, whereas the DM prevalence rates for the two groups were 3.95% and 8.54%, respectively **(141).**

Our study showed that both men and women with DM had a significantly greater mean weight, BMI, WC and WHR. In addition, in both sexes, study subjects with DM had higher rate of general obesity (defined by BMI) and central obesity (defined by WC and WHR) compared to non DM subjects.

Compare the diagnostic performance of anthropometric indices for predicting DM and determining the optimal cut-off points for each index.

This is one of the few studies in the south Asian region to evaluate and compare the predictive ability of anthropometric indices of obesity and also define the optimal cut-off values of BMI, WC, and WHR for predicting diabetes in rural Bangladesh. Study findings support that each central obesity indicator, WC and WHR, is strongly and independently predicted risk of diabetes in both gender compared to general obesity as measured by BMI. In the Asian population, this has been verified by a number of studies as well as pathophysiological mechanism of diabetes. Based on prospective and cross-sectional studies, BMI, WC, WHR have each been identified as an independent risk factor for DM in the Bangladeshi populations studied. Previous reports have also shown that central obesity is a stronger predictor of the development of DM in Bangladeshi study subjects **(59, 114-116).** It has been shown that central obesity plays a vital role in the pathogenesis of insulin resistance **(148),** increased plasma leptin, low plasma adiponectin **(149)** and stimulation of inflammatory cytokines **(150).** All of these factors lead to development of diabetes and other cardiovascular diseases.

The optimal cut-off values in this study for BMI were 21.2 kg/m^2 for men and 21.8 kg/m^2 for women to predict diabetes which also evident in previous studies in Bangladesh. These values are lower than the values recommended for western populations, (BMI ≥25 kg/m^2 for overweight and BMI ≥30 kg/m^2 for obesity), and, for Asia-Pacific populations **(33,107)** (BMI ≥23 kg/m^2 for overweight and, BMI ≥25 kg/m^2 for obesity). Our optimal value of 82 cm for WC in both men and women is lower than the cut-off levels recommended by IDF for Asian populations **(45).** In contrast, IDF values are lower for WHR than our results for a WHR of 0.93 for men and 0.87 for women in this study. In the present study, it was confirmed that the WHR, a measure indicative of central obesity, is a most sensitive risk indicator of DM in both sexes which was also marked in previous studies in Bangladesh **(59,115).** The observations from INTERHEART study indicate that WHR shows strongest association with cardiovascular risk (myocardial infarction) compared with BMI or WC across 52 populations from every continent **(113).** Study in India showed that abdominal obesity based on WC is a better predictor of DM compared to WHR **(151).**

Both the odds ratios (ORs) and AUC values for BMI, WC, and WHR were higher for women than for men for diabetes. Our findings related to AUC were similar to the recent meta-analysis conducted by Lee et al**. (109)** and Dong et al **(152).** Unadjusted and adjusted odds ratios were very similar in our study which suggested that these indices were independent risk factors.

The Thai study revealed that WC and WHR were more strongly associated with diabetes than were weight and BMI **(153).** The InterASIA study analyzed that central obesity was more closely related to diabetes than was overall obesity and also demonstrated that both WHR and WC were equally important for predicting DM and IFG in the Chinese population **(141).**

Chapter 6: Conclusions, Recommendations and Future Research Implication:

6.1 Conclusions

The prevention and control of obesity in developing countries need urgent attention since the disease is expected to double in these countries in the next 20 to 25 years. The burden of obesity in Bangladesh is also increasing rapidly as like as the whole world. From the perspective of Bangladesh overweight and obesity can be turn into big social issue. As the problem of obesity has increased substantially in the past decade, there is an urgent need for a national strategy for health promotion towards the reduction of overweight and obesity among the Bangladeshi people. The age standardized prevalence of overweight and obese based on BMI were 17.7%, and 26.2%, respectively and central obesity based on WC and WHR were 39.8% and 71.6% respectively. The result also shows that prevalence of central obesity was more in female than male. Study shows middle age, medium and high SES, primary, secondary and higher education, physical inactivity, high consumption of carbohydrate, protein and fat, were some significant risk indicators for generalized and central obesity. Study also indicated that indices of central obesity predicted better cardiometabolic risk factors than general obesity defined by BMI for both men and women.

Government and also related authorities need to plan about the awareness program in different areas of our country for preventing the obesity and its related cardiometabolic diseases. More large scale studies with control populations including all the possible influences are required to confirm our findings.

6.2 Recommendations

The results presented in this study generated several issues that warrant further evaluation. In a developing society like Bangladesh, where the resources are really limited relative to its population size, the increasing life expectancy and elevated prevalence of obesity and many others chronic disease like diabetes will dramatically raise the disease burden and expenses of the health care system. In order to prevent this burden the community needs to be mobilized. So everybody needs to be aware of the risk factors.

In order to address this issue large-scale cohort studies are needed with a control population. As this is the first report from Bangladesh concerning obesity in adult Bangladeshi, our results need to be confirmed through studies performed in different regions in Bangladesh at regular intervals in order to be able to assess the probable rate of increase prevalence so that an effective obesity prevention program can be introduced for reducing obesity burden. Additional obesity prevalence surveys should be carried out in different socioeconomic classes in Bangladesh at regular intervals in order to be able to assess the probable rate of increases obesity. Also, public health intervention should be focused on the control and prevention of obesity in children through an integrated community approach. Some recommendations:

- There is need to develop a community based program, which would aim at minimizing the risk factors of obesity. This program should promote the prevention of obesity by providing culturally sensitive educational messages. Health education activities included healthy life styles like proper diet (avoidance of high calorie food, high intake of fat etc), regular physical activity more than 30 minutes per day on all days of week. Established principles and practices of health and general education should also be included in a community based program.
- Mass screening programs for the whole population in the communities with the help of Government and non-government agencies (NGO's) should be carried out regularly to detect pre-obese and obese people in the community. Training of paramedical personnel and health workers regarding assessment of obesity should also be undertaken. By holding camps in rural areas, population at periphery and at distant places can be made aware about obesity, its causes, consequences and prevention.
- Primordial prevention is an important level in prevention of obesity and other non-communicable diseases. This can be achieved by inculcating healthy habits in the younger population, as risk of obesity is to originate in the childhood. And hence primordial prevention related health education activities should be regularly conducted as a part of school and college health services involving active participation of teachers to prevent emergence of risk factors for obesity and other non-communicable diseases.
- The food industry can play a significant role in promoting healthy diets by:

- reducing the fat, sugar and salt content of processed foods;
- ensuring that healthy and nutritious choices are available and affordable to all consumers;
- practicing responsible marketing especially those aimed at children and teenagers;
- ensuring the availability of healthy food choices and supporting regular physical activity practice in the workplace.

6.3 Future Research Implications

In a setting with limited health and financial resources, and in a situation where lifestyles appear to be changing in unhealthy directions, the findings of high prevalence of obesity make primary prevention of the obvious strategy of choice. Much needs to be done on the different fronts of the policy making, program implementation, and research. In the area of research, this study points to the following needs:

1. The present study will provide baseline data regarding the prevalence and risk factors of both general and central obesity in adult Bangladeshi population.
2. The present study will provide baseline data regarding the association of obesity and T2DM in adult Bangladeshi population.
3. This study findings will help to create baseline information's for future cohort study.
4. Help to generating hypothesis.
5. The results of the current study may lay the foundation of awareness to develop policies in order to address the challenges to prevent overweight and obesity.
6. Necessary data for "Global atlas on diabetes"
7. Provide baseline information regarding identification of suitable anthropometric indices for predicting Type 2 diabetes for adult Bangladeshi population
8. Provide baseline information regarding Identify the optimal cut-off values of anthropometric indices for defining general and central obesity suitable for Bangladeshi population for future cohort study.

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List of Appendix

Appendix I: Community Awareness Leaflet

Chandra Rural Diabetes Study

A joint research program of Diabetic Association of Bangladesh and University of Oslo

Know and Inform

Like all other countries Diabetes and associated risk of Stroke, Heart Disease, Blindness, Kidney Failure and Leg Amputation is increasing in Bangladesh. Diabetes Association of Bangladesh and University of Oslo jointly organize a free screening program in your locality. We are inviting you to come and check your condition.

Who will join?

1. Age ≥20 years
2. Resident of this area
3. Not pregnant or not conceive
4. Not suffering from any acute or chronic disease

What will happen at the study site?

First: - Appointment will be made beforehand with all the participants in the study by fieldworkers, in order to guarantee the most appropriate time for each participant.

Second: - At the study site, the participant will be registered and will go through the following steps:

1. A rapid blood test in fasting state (FPG) followed by drinking a glucose solution for persons who are not diagnosed with diabetes previously. After 2 hours of glucose drink another blood test will be performed.
2. Measurement of blood pressure, height, weight, and other body measurements
3. Filling out a health related questionnaire
4. Total 11 ml (2 and half tea spoon) blood will be drawn for the following tests:
    - Fasting and 2-h plasma glucose
    - HbA_{1c} (average blood glucose for last 3 months)
    - Fasting lipids (Total cholesterol, LDL, HDL and Triglycerides)
    - Serum insulin

Who will collect your blood?

Trained phlebotomists from Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM) Hospital will collect your blood samples.

Where will be the blood test analysed?

All the blood test will be sent to BIRDEM hospital for analysis.

When will participants receive the test results?

You can come to the study site within a week of taking the blood sample to receive the results. Test results that have not been claimed will be distributed to each participant at the end of the study.

How will be the results handled?

Results will be handled with complete confidentiality, as sample will be sent to the laboratory with a special number (a code) given to each participants.

What will happen to found to have diabetes or pre-diabetes people?

- Pre-diabetes: will be enrolled at free Diabetes Prevention Program, a joint diabetes prevention program of UIO and DAB.
- Diabetes: will be registered at free of cost in the nearest diabetes centre (Chandra Diabetes Centre, Gazipur) for further follow-ups.

To participate in the study, please make an appointment with fieldworkers and follow the instructions provided in the attached personal invitation.

We welcome you at study site for any questions or clarifications

With Regards,

Coordinator

Chandra Rural Diabetes Study Program

Diabetic Association of Bangladesh

Appendix II: Personal Invitation Letter

Chandra Rural Diabetes Study

A joint research program of Diabetic Association of Bangladesh and University of Oslo

Personal Invitation Letter

Dear Mr/Mrs……………………………..

Greetings,

We would like to remind you of the importance of presenting at the site of Chandra Rural Study Project that is administered by the Diabetic Association of Bangladesh and University of Oslo, Norway. Please be attendance on (day)…….(date)…….(hour)…… in order to proceed with the steps of the field investigation.

We would also like to remind you of the importance of adhering strictly to the appointment and to the following guidelines:

1. Abstaining from all kinds of food and drinks with the exception of water 12 hours before coming to the research site.
2. Adhering to the day and time that will be given to you by the research team.
3. If you are on any kind of medications and prescription (s) of recently visited physician (s), please bring them with you to the screening site to show to the investigating team.
4. Please bring your national identification card when coming to the site.

We thank you for your participants……

With Regards,

Coordinator

Chandra Rural Diabetes Study Program

Diabetic Association of Bangladesh

Appendix III: Consent Form

Informed consent from

You are being invited to participate in a Diabetes Research study. This form is designed to provide you with information about the study. The investigators or representative describes this study to you and answer any of your questions.

Title of project: “*Ten Years Follow-up for Diabetes in Indian-Asian Population: A Study from Bangladesh*”

Investigator (s):…………………………………………………………………..

Address: ……………………………………………………………………………

Phone No:…………………………………………. Co-Investigator (s):……………….……………….

This is to certify that I, ………………………………………………………., hereby agree to participate as a volunteer in an authorized research project.

I understand the purpose of this research as mentioned above. I have been informed about diabetes and its acute and long-term effects on our body especially on eye, brain, heart, kidney, feet and nerve etc. During examination day I have to visit a selected area near my home in fasting state. Beside routine physical examination they will collect one tea spoon (5 ml) fasting blood from my vein. Then I have to drink a glass of glucose and after 2 hours they will again collect half spoon (3 ml) blood. My mental condition and dietary information’s will also be collected. They will provide all of my investigation reports and necessary advice.

I understand that all the information which is obtained from me will be confidential in an appropriate manner.

Participation is voluntary and I understand that I am free to refuse to participate in a procedure or to refuse to answer any question at any time without prejudice to me. I understand that I am free to withdraw my consent and to withdraw from the study any time without prejudice to me.

I understand that the research investigators named above will answer any of my questions about the research procedures, my rights as a subjects and research-related injuries time.

I understand that I will be given a copy of this consent form if I so request.

Name and signature of participant or responsible Agent /Date

…………………………………………………………………………..

…………………………………………………………………………..

Note: If you have any questions or complaints about the informed consent process or policy, please contact investigators (s). **Thank you!**

Appendix IV: Questionnaire of Chandra Rural Diabetes Study

Chandra Follow-up Study
Bangladesh Diabetic Somity & University of Oslo

Questionnaire

1.1 Date ☐☐☐☐☐☐ 1.2 ID ☐☐☐☐

1.3 House no ☐☐☐☐☐

2. Personal History

2.1 Name of the Patients ____________________

2.2 S/o, W/o, D/o ____________________

2.3 Age in years ☐☐

2.4 Sex (1. Male 2. Female) ☐ 2.5 Marital Status (1. Married 2. Single 3. Widow) ☐

2.6 Occupation (1. Administrative 2. Business 3. Skilled labour 4. Manual Labor
5. Home Duties 6. Farmer 7. Unemployed 8. Pensioner 9.Others) ☐

2.7 Participation in screening program : 1999 ☐ 2004 ☐ New ☐

2.8 **Address**

2.8.1 Village ____________________ 2.8.2 Upzilla ____________________

2.8.3 Post ____________________ 2.8.4 District ____________________

2.9 **Phone Number**

2.9.1 Home ☐☐☐☐☐☐☐☐☐

2.9.2 Mobile ☐☐☐☐☐☐☐☐☐☐☐

3.0 Educational Status (yrs of education) ☐☐

4 Socio-economic History

4.1 Earning capacity (1. Earner 2. Dependent)

4.2 No of earners in the family

4.3 No of family members sharing the same kitchen

4.4 Total family monthly expenditure

5. Personal History

5.1 Family history (Yes =1, No =2, Unknown=3)

	1. DM			2. HTN			3. IHD			4. Stroke		
	1	2	3	1	2	3	1	2	3	1	2	3
Grand parents												
Father												
Mother												
Brother/sister												
Sons/daughters												

5.2 **Any Addiction?** (Ex= more than 6 months)

Name	(1. Y 2. N 3.Ex)	No/ Amount	Name	(1. Yes 2. No 3.Ex)	No/ Amount
A. Cigarettes			D. Alcohol		
B. Chews Tobacco			E. Other		
C. Hukka					

5.3 Any sort of physical movement (hours/day)
(N.B Farmer, rickshaw/van puller, wood-cutter =100%;
All household work except wood-cutter =50%)

6. History of Past illness

6.1

SL	Name of Diseases	(Yes =1, No =2, Unknown=3)& date of diagnosis	Are you currently taking any medication (1. Yes 2. No)	Medicine Name
A	Diabetes			
B	High blood pressure			
C	Stroke			
D	Heart Attack			
E	Foot ulceration			
F	Claudication			
G	Vision problem			
H	Other specify			

6.2 Obstetric History

6.2.1 Total number of children ☐ 6.2.2 Number of Still Births ☐

6.2.3 Number of Miscarriages/ Abortions ☐ 6.2.4 Age of last child ☐

7. Physical Examination

Blood Pressure

7.1 1st BP SBP ☐☐☐ DBP ☐☐☐

7.2 2nd BP SBP ☐☐☐ DBP ☐☐☐

7.3 Weight in kg ☐☐☐ 7.4 Height in cm ☐☐☐

7.5 Waist in cm ☐☐☐ 7.6 Hip in cm ☐☐☐

8. Blood test results:

Name of the test	**Result**
7.1 FPG level (mmol/l)	
7.2 2hAG (mmol/l)	
7.3 HbA1c %	
7.4 Total Cholesterols mg/dl	
7.5 Triglyceride mg/dl	
7.6 HDL mg/dl	
7.7 LDL mg/dl	
7.8 Fasting Insulin Levels	
7.9 Serum Leptin	

9. 24 h- recall method (processing, amount (household), amount (gram), factor)

Time	Processing/ Name of food	Amount (household)	Amount (g)	factor	
Early mor					
Breakfast					
Mid mor					
Lunch					
Evening					
Dinner					
Bed time					

Total oil consumption/month

10. Depression Scale

No	Question and Filters	Coding Categories	Code
1	Apparent Sadness Representing despondency, gloom and despair reflected in speech, facial expression, and posture.	No sadness ………….. Looks dispirited but does brethren up without difficulty ……….. Appears sad and unhappy most of the time ……………… Looks measurable all the time	0 1 2 3 4 5 6
2	Report Sadness Representing reports of depressed mood, regardless of whether it is reflected in appearance or not.	Occasional sadness in keeping with the circumstances …………….. sad or low but brightens up without difficulty …………….. Pervasive feeling of sadness or gloominess …………….. Continuous or unvarying sadness , misery or despondency	0 1 2 3 4 5 6
3	Inner Tension Representing feeling of ill defined discomfort, edginess, and inner turmoil, mental tension mounting to panic, dread or anguish.	Placid .Only feeling inner tension …………………… Occasional feelings of edginess and ill Defined discomfort …………………….. Continuous feeling of inner tension intermittent panic …………………….. Overwhelming panic	0 1 2 3 4 5 6
4	Reduced Sleep Representing the experience of reduced duration or depth of sleep compared to patients own normal pattern when well.	Sleep as usual ………………. Slight difficulty dropping off to sleep or slightly reduced ………………………. Sleep reduced or broken by at least two 2 hours ………………. Less then two or three hours sleep	0 1 2 3 4 5 6
5	Reduced Appetite Representing the feeling of a	Normal appetite Increased appetite Slightly reduced appetite	0 1 2

	loss of appetite compared with when well.	Sometimes increased appetite No appetite. Food is tasteless ………………………… Need persuasion to eat at all	3 4 5 6
6	Concentration Difficulties Representing difficulties in collecting ones thought mounting to inspecting lack of concentration.	No difficulties in concentration …………………….. Occasional Difficulties in collection of one s thought …………………………….. Difficulties in concentration and sustaining thought …………………… Unable to read or converse without great difficulty	0 1 2 3 4 5 6
7	Lassitude Representing a difficulty getting started or slowness thought initiating performing ever day activities.	Hardly any difficulties in getting started. No sluggishness without any difficulty Difficulties in starting activities ………………………… Difficulties in starting simple routine activities ……………… Complete lassitude. Unable to do anything without help .	0 1 2 3 4 5 6
8	Inability Representing the subject experience of reduced interest in the surroundings, or activities that normally give pleasure.	Normal interest in surroundings in and other people …………………… Reduced ability to enjoy usual interest ………………………………… Loss of interest in surroundings ……………………………….. The experience of being emotionally paralyzed, inability to feel anger, grief or pleasure.	0 1 2 3 4 5 6
9	Pessimistic Thought Representing thoughts of guilt, inferiority, self reproach, sinfulness, remorse and ruin.	No pessimistic thoughts …………………….. Fluctuating ideas of failure , self reproach ……………………………….. Persist self accusations , rational ideas guilt or sin …………………………………… Dilutions to ruin , remorse self accusations	0 1 2 3 4 5 6
10	Suicidal Thoughts Representing the feeling that life is not worth living , that natural dept would be welcome , suicidal thoughts and preparations for suicide	Enjoy life for takes it as it comes …………………………… Weary of life. Only feeling suicidal thoughts …………………………… Probably better off dead .Suicidal thoughts are common …………………………………… Explicit plan for suicide when there is an opportunity	0 1 2 3 4 5 6

Appendix V: Ethical Permission from Regional Ethical Committee, Norway

Region:	Officer:	Phone:	Our date:	Reference:
REC south-east	Gjøril Bergva	22845529	03.07.2013	2013/1016/REK sør-øst D
			Your date:	
			28.05.2013	

To Tasnima Siddiquee

2013/1016 Prevalence of overweight and obesity and its associated risk of diabetes in a rural Bangladeshi population.

In reference to your application reviewed by the Committee on the 13th of June 2013.

Chief Investigator: Tasnima Siddiquee
Institution responsible: University of Oslo

Project description
Developing countries are increasingly vulnerable to the worldwide epidemic of obesity and diabetes. Obesity is a modifiable risk factor for type 2 diabetes (DM). Population-based data on the prevalence of obesity in rural Bangladeshi adults based on proposed cut off points for Asian population have been lacking until recently. The purpose of the study, which is a retrospective epidemiological study, is to determine the prevalence of obesity and its associated risk of diabetes in rural Bangladeshi population. Data will be ectracted from Chandra Rural Diabetes Study, a population-based cross-sectional study conducted in March 2009 to December 2009. Prevalence of obesity and its diabetes risk will be assessed and their relationships will be examined.

Committee's considerations
The Committee reviewed the application during its meeting on 13 June 2013. The project was assessed in accordance to the Norwegian Research Ethics Act of 30 June 2006 and Act on medical and health research (the Health Research Act) of 20 June 2008 for the regional committees for medical and health research ethics.

The Committee has no objections that the project is conducted as described in the application and the protocol. The Committee presumes that Professor Akhtar Hussain is chief investigator, not the student.

It is stated in the application under point 5 that "Data registered in the research project are directly identifiable". The Committee requests that the data must be stored as de-identified data, i.e. with identifying information kept separate from the other data.

The Committee's decision
The project is approved on condition that it is conducted as described in the application and the protocol.

The approval is valid until 31.12.2013. The data must be stored as de-identified data, i.e. with identifying information kept separate from the other data. For purposes of documentation, the data shall be kept until 31.12.2018, and deleted or anonymized after this date.

The decision of the committee may be appealed to the National Committee for Research Ethics in Norway.

The appeal should be sent to the Regional Committee for Research Ethics in Norway, South-East D. The deadline for appeals is three weeks from the date on which you receive this letter.

Yours Sincerely,

Stein A. Evensen
Prof. dr. med.
Chair of the Regional Committee for
Medical Research Ethics of Southern Norway (P.P.)
Section D

Gjøril Bergva
Advisor

Copy: hussain.akhtar@medisin.uio.no; universitetsdirektor@uio.no